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JANUARY 29, 1954

Launch of P. and O. Liner "Iberia"

LADY MCGRIGOR, wife of Admiral of the Fleet, Sir Rhoderick McGrigor, G.C.B., performed the naming ceremony of the "Iberia," which was launched on Thursday, January 21st, from the Musgrave yard of Harland and Wolff, Ltd., Belfast. The 28,000-ton liner, which is being built for the Peninsular and Oriental Steam Navigation Company, is a sister ship of the "Arcadia," which will sail shortly on her maiden voyage. Speaking after the launch, Sir Frederick Rebbeck, the chairman and managing director of the builders, mentioned the difficulties of securing new orders which he said were practically unobtainable. He admitted that there was plenty of work for 1954 but that fact did not give cause for complacency for he emphasised that work on the designs of ships to be delivered many years hence should now be in hand and was not. After making brief reference to the question of cancellations of orders, which were relatively small but significant, Sir Frederick advised the adoption of a more realistic outlook and went on to draw attention to the growing foreign competition in construction and repair work. In support of his contention, he mentioned that for twenty-four years his company had had the largest output and that in 1952 a Swedish yard succeeded to that position while the returns for 1953 showed that the output list was headed by two Swedish and two German yards and one American yard. Sir William Currie, the chairman of the P. and O. Company, once again voiced the claim of shipping for special taxation treatment, mentioning that his company's passenger fleet had shrunk from twenty-one ships of 378,000 tons, before the war, to eleven ships of 245,000 tons to-day. Continuing, Sir William gave support to Sir Frederick Rebbeck's remarks about foreign competition by stating that a Continental yard had offered to build a 10,000-ton cargo ship within a period of twelve months at a price 10 per cent less than that possible in Great Britain. The "Iberia" has the same dimensions as the "Arcadia," namely, 718ft 9in length overall by 90ft 6in beam.

Productivity in the Valve Industry

THE British Productivity Council has published a review of recent progress in industrial valve manufacturing. A team representing the steel, iron and non-ferrous valve manufacturing industry visited the U.S.A. in 1950, and its report was published in the following year. The report urged, among other matters, that the valve industry in this country should pay more attention to the advantages of specialisation, standardisation and simplification, suggested that there was need for more extensive mechanisation in the handling of valves and components, and recommended that the utilisation of existing machines should be improved. The review which has now been published says that the annual output of the valve industry, which is valued at over £26,000,000, is more than five times greater in value than it was in 1946. Although there are about 200 companies in the United Kingdom which manufacture valves, it is claimed that well over three-quarters of the total production comes from the sixty member-firms of the British Valve Manufacturers Association. The review goes on to say that many companies in the industry are in the middle of reorganisation which is likely to increase their efficiency still further, that others have given careful consideration to the effect of design on ease of production, and that some firms have "streamlined" their organisation and established production planning and control departments. Where possible, it is stated, firms have tried to arrange a proper flow of production and to cut down the amount of handling between operations. The layouts of foundries, machine shops and assembly shops have been improved, and many foundries have been mechanised. In addition, the review notes, a great deal of machinery has been installed, which has the effect of ensuring closer tolerances than were possible with some of the machines previously in use. The review can be obtained from the British Productivity Council, 21, Tothill Street, London, S.W.1, price 2s.

Graphical Solution of Transient Vibration Problems

A PAPER "On the Graphical Solution of Transient Vibration Problems," by Dr. R. E. D. Bishop, was presented and discussed at the Institution of Mechanical Engineers in London on Friday, January 22nd. In this paper the author dealt with the application of phase-plane methods to dynamical systems with transient loading. He surveyed the literature covering the twenty years since these constructions were introduced: this review included the transient disturbance of single-degree-of-freedom systems and of multi-degree-of-freedom systems; the deflections of beam columns in the theory of elastic stability and Jacobsen's general method of graphical integration. The author also gave some recent extensions of the theory: a method of graphical differentiation; a simplified approach to multi-degree-of-freedom systems leading to the treatment of transient loading of beams by moving and moving-and-varying loads. He suggested that damping may be contemplated in such beam problems and that the method devised had some bearing on certain plate problems. Finally, he showed that the graphical method could be used for deflections, as well as bending moments, in the theory of beam columns.

Institution of Mining Engineers

YESTERDAY, the sixtieth annual general meeting of the Institution of Mining Engineers was held in London. The annual report of the council, which was presented at the meeting, showed that at July 31, 1953, the total membership of the Institution was 4124, which indicated a net increase of 345 during the preceding twelve months. At the meeting, Major Noel E. Webster assumed office as president in succession to Mr. J. Cecil Mitcheson, and at the conclusion of the formal business delivered his presidential address, which was entitled "An Appeal to Youth." In the course of his address, Major Webster said that, despite the increasing degree of mechanisation, mining was still a great human industry, for as an extractive rather than a processing industry it required a heavy manpower to run it. A most important task of those who directed it, therefore, was in the handling of men, a responsibility which called for the highest quality of leadership. In the study of mining engineering and its application in practice, Major Webster continued, mining engineers must certainly become technologists; equally obviously it was important that they should achieve material gain, but in those joint processes they also became great humanists. Further, the implementation of the National Plan for Coal, which was an imaginative approach involving heavy capital expenditure, offered tremendous opportunities to well-trained young men in all branches of engineering—mining, mechanical, electrical, civil and chemical.

Lloyd's Shipbuilding Returns

LLOYD'S REGISTER OF SHIPPING has issued its shipbuilding returns for the quarter ended December 31, 1953. In Great Britain and Northern Ireland there were 313 steamships and motorships of 2,173,709 tons gross under construction, and of this total 88 ships of 650,563 tons were fitting out, while 225 ships of 1,523,146 tons were yet to be launched. During the quarter 55 ships of 334,451 tons were commenced and 55 ships representing 366,145 tons were launched, while the completions totalled 57 ships of 363,687 tons. The tonnage of oil tankers decreased by 27,122 tons to 1,151,404 tons, representing 98 ships and 53 per cent of the tonnage under construction. Plans have been approved and material ordered for 2,157,830 tons, a decrease of 128,344 tons since the previous quarter. Excluding China, Russia and Poland work in hand abroad totalled 823 ships of 4,121,167 tons gross, representing an increase of 320,067 tons on the September quarter, and during the quarter 265 ships of 1,292,343 tons were commenced, 252 ships of 1,129,163 tons were launched, and 240 ships of 985,289 tons were completed. Compared with the preceding quarter the tonnage commenced increased by 580,527 tons and the tonnage completed increased by 151,415 tons. The oil tankers under construction increased by 186,914 tons to 2,397,503 tons, representing 207 ships and 58·2 per cent of the tonnage building abroad. Throughout the world 1136 steamships and motorships of 6,294,876 tons gross, an increase of 303,447 tons, were under construction, of which 34·5 per cent were building in Great Britain and Northern Ireland. A total of 305 oil tankers of 3,548,907 tons were building, which amounted to 159,792 tons more than the previous quarter and to 56·4 per cent of the world tonnage. The ships being built in the world at the end of December included 98 of between 6000 to 8000 tons, 75 between 8000 to 10,000 tons, 164 between 10,000 and 15,000 tons, 51 between 15,000 and 20,000 tons, and 41 ships between 20,000 tons and 30,000 tons. The merchant ships under construction to the inspection of Lloyd's Register amounted to 4,161,145 tons, or 66·1 per cent of the world tonnage, including 2,102,425 tons, or 51·0 per cent, of the tonnage building abroad.

Merchant Shipping Bill

LAST week the Merchant Shipping Bill was presented in the House of Commons by Mr. A. T. Lennox-Boyd. It has as its purpose the amending of the existing law, which provides for the measurement of the space occupied by the propelling machinery and the amount of deduction allowed from the gross tonnage. The Bill is particularly concerned with the spaces occupied by boilers and machinery which do not exceed 13 per cent for propeller-driven ships, or 20 per cent for those propelled by paddle wheels. Under existing regulations, where the volume of the propelling machinery space lies between the limits of 13 and 20 per cent of the gross tonnage, the amount allowed for deduction is 32 per cent of the gross tonnage. However, should the propelling machinery space be under 13 per cent the allowance is one and three-quarter times the actual tonnage of the space. The Bill provides for the continuation of a deduction of 32 per cent for machinery spaces amounting to 13 per cent of the gross tonnage, but proposes that where the amount is less than 13 per cent then the 32 per cent deduction should be proportionately reduced. In similar manner, the Bill proposes that for paddle steamers the allowance of 37 per cent for machinery spaces measuring 20 per cent of the gross tonnage shall be continued, but with proportionate allowances for spaces under 20 per cent. A clause in the Bill covers the possibilities of designers making the spaces too small by stating that the allowance will not be granted unless the ship surveyor is satisfied that the space allocated to the propelling machinery is adequate for the working of the machinery and for lighting and ventilation.

High Temperature Turbine Machinery for Marine Propulsion

(*Continued from page* 127, *January* 22*nd*)

No. II—GAS TURBINES

By T. W. F. BROWN, D.Sc., S.M., M.I.E.E.*

In this continuation of abstracts reprinted from the Thomas Lowe Gray lecture, presented by the author before the Institution of Mechanical Engineers on Friday, January 15th, the development of the gas turbine for marine use is discussed. The cooled gas turbine is particularly studied and shown to have greater potentialities for improvement than the steam turbine.

The Gas Turbine for Marine Use

MANY summaries of the position of gas turbines in Britain and overseas have been made from time to time, and no attempt will be made to produce another. Quite the best is the series given as "Gas Turbine Progress Report, 1952." Three of the twelve papers apply specifically to marine aspects: marine, merchant vessels and naval vessels. One of the points on which information is lacking has been actual figures obtained on test and reports on running experience gained. In uncooled gas turbines of the multi-stage long-life type, inlet temperatures do not greatly exceed 1250 deg. Fah. (677 deg. Cent.). With some air cooling of the turbine rotor at inlet, or cooling pads fitted adjacent to the turbine disc (cooling by radiation), temperatures increase to 1450 deg. Fah. (788 deg. Cent.) as a maximum for long-life operation. In this lecture only long-life gas turbines required for ship propulsion will be considered.

The Pametrada marine gas turbine developing 3500 s.h.p., which was designed in 1946 and which has been operating since December, 1948, is quite the most useful tool which could have been devised to examine the problems of distortion, controls, component efficiencies, the combustion of residual fuels and the related matters of "build-up" and corrosion. New mechanical parts such as glands, pipe joints, &c., have also been proved. Details of the cycle and construction have been given in a previous paper (Brown, 1949).

The set has now been coupled through hydraulic couplings and reduction gear to the large brake (60,000 b.h.p. at 160 r.p.m.). At the designed main shaft speed at full load of 85 r.p.m., a power of 3500 s.h.p. represents about one-quarter load on the brake at this speed owing to the operation of the "propeller law." Typical test results under different conditions are given in Table V.

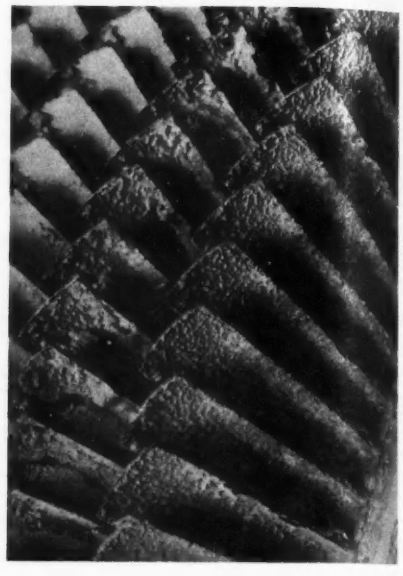
The values quoted under turbine efficiencies are calculated from pressures, flows and work done.

The runs were carried out under the conditions shown in Table VI.

Test results in columns A–E inclusive give the readings from normal runs to examine the efficiency of the compressors, intercooler, turbines, and heat exchanger. It will be seen that the low-pressure compressor has an efficiency of about 79 per cent. This was due to mismatching of the components, the original compressor being too large. By cutting down the rotor blade heights, filling in the annuli between fixed blading with rings and fitting spacers between blades, the capacity was corrected, but the efficiency suffered. If the low-pressure compressor were redesigned an efficiency of 87 per cent should be possible. This would produce an increase of about 11 per cent in thermal efficiency and 13·5 per cent in specific power, and the overall thermal efficiency would become 31 per cent. Even now the figure for specific fuel consumption in column A is the lowest known to the author. As corrected it would certainly be better than a steam turbine plant of this output with an inlet temperature of 1000 deg. Fah. It will be apparent that this experience of operation at 1250 deg. Fah. is available for improvements in steam turbines to operate at similar temperatures, particularly if two-stage reheat is employed when similar pressure and temperatures will occur at the lower reheat position.

Table V—*Test Results Under Varying Conditions for Pametrada* 3500 *s.h.p. Marine Gas Turbine*

Run	A	B	C	D	E	F	G
Atmospheric conditions :							
Pressure, pounds per square inch absolute	14·92	14·7	14·7	14·7	14·69	14·53	14·74
Temperature, degrees Fahrenheit absolute	486	517·4	518	518·7	533·5	512·3	505·8
Mass flow to low-pressure compressor (corrected to 80 deg. Fah., 14·7 lb per square inch absolute), pounds per second	47·7	47·0	46·45	46·4	47·8	47·1	42·9
Low-pressure compressor :							
Inlet pressure, pounds per square inch absolute	14·73	14·53	14·53	14·53	14·51	14·36	14·58
Outlet pressure, pounds per square inch absolute	30·62	29·71	29·81	29·72	29·08	30·02	33·94
Outlet temperature, degrees Fahrenheit absolute	627·5	668·5	666·8	666·0	684·1	662·3	668·6
Efficiency, per cent	79·7	78·3	79·4	79·6	77·6	80·5	85·0
Mass flow to high-pressure compressor (corrected), pounds per second	48·8	47·6	47·1	47·1	49·45	46·8	38·6
High-pressure compressor :							
Inlet pressure, pounds per square inch absolute	29·8	29·18	29·09	28·98	28·20	29·26	33·33
Inlet temperature, degrees Fahrenheit absolute	532	540·9	539·3	538·5	543·8	534·9	542·5
Outlet pressure, pounds per square inch absolute	81·42	76·7	75·45	74·7	74·69	78·73	86·24
Outlet temperature, degrees Fahrenheit absolute	725·5	733·7	728·7	725·8	736·9	731	741·8
Efficiency, per cent	91·3	89·5	88·6	89·2	90·0	89·1	85·0
High-pressure turbine plus compressors : speed, revolutions per minute	4495	4428	4395	4380	4530	4390	4260
High-pressure turbine :							
Mass flow, pounds per second	49·1	46·46	46·04	45·94	46·62	46·07	42·92
Inlet pressure, pounds per square inch absolute	78·67	74·2	72·93	72·45	72·12	76·23	84·44
Inlet temperature, degrees Fahrenheit absolute	1599	1638	1618	1615	1568	1660	1654
Outlet pressure, pounds per square inch absolute	28·15	26·81	26·41	26·34	24·28	26·54	25·22
Outlet temperature, degrees Fahrenheit absolute	1261	1302	1286	1285	1220	1318	1294
Efficiency, per cent	84·9	86·3	85·9	85·4	84·75	83·1	77·25
Low-pressure turbine :							
Inlet pressure, pounds per square inch absolute	27·84	26·20	25·81	25·78	23·78	—	—
Inlet temperature, degrees Fahrenheit absolute	1620·5	1639	1592	1617	1213	—	—
Outlet pressure, pounds per square inch absolute	15·17	14·95	14·94	14·93	14·90	—	—
Outlet temperature, degrees Fahrenheit absolute	1413	1446	1407	1429	1082	—	—
Efficiency, per cent	84·6	83·7	82·0	83·2	82·0	—	—
Shaft horsepower	3588	3171	2972	2980	1937	—	—
Fuel consumption, pounds per hour	1755	1680	1596	1599	1322	—	—
Specific fuel consumption, pounds per shaft horsepower-per hour	0·488	0·530	0·538	0·536	0·684	—	—
Thermal efficiency, per cent	28·95	26·7	26·3	26·4	20·7	—	—
Heat exchanger thermal ratio	80	80	83·6	80	77·3	74·3	80·1
Reduction in swallowing capacity, per cent	—	—	—	—	—	3·57	20·40



(*a*) Rotor Blading

(*b*) Casing blading

Fig. 8—*Condition of Gas Turbine Rotor and Casing Blading after* 84*-hour Run on Heavy Fuel Oil*

Residual Fuel Burning.—Investigations into the problem of residual fuel burning began on a laboratory scale with attempts to remove ash-bearing constituents in the fuel by a two-stage centrifuging process, by use of butane, propane, phenol and aniline as solvents, by the action of concentrated sulphuric acid, and by other means. This series of attacks on the problem was abandoned as none of the solvent methods showed any promise of removing the ash-bearing constituents from residual oils except at a prohibitive expense, and as the results

* Research Director, the Parsons and Marine Engineering Turbine Research and Development Association (Pametrada).

of the centrifuging trials were also negative. Studies on inhibition of the corrosion caused by vanadium and sodium-bearing fuel ashes were therefore started. Samples of all commonly used high-temperature alloys were obtained. It was shown that, of all the substances used for inhibition, magnesium oxide, zinc oxide and vermiculite (a complex mica-like silicate) were capable of reducing the attack to satisfactory proportions, while kieselguhr and alumina were effective but not so good. A serious warning arose, however, from these tests in that, with the exception of magnesium compounds, all the additives were not only capable of failing to reduce the corrosion, but could also bring about accelerated attack when present in certain critical proportions. These laboratory investigations have been reported by two of the author's colleagues (Frederick and Eden, 1954). Rig tests were then carried out with a small combustion chamber fitted to burn fuel oil, a chemical pump adding the inhibitors to the fuel before spraying, and into the spray. The resulting gas was discharged from the combustion chamber on to target specimens fitted with thermo-couples. The correlations between laboratory and rig tests were good.

This experience enabled running tests to begin on the 3500 s.h.p. gas turbine using Admiralty reference fuel " Mothball." This was the worst residual fuel found in laboratory tests. The ash content is 0·05 per cent, of which 60 per cent can be reduced to vanadium pentoxide by analysis. Columns F and G represent the beginning and end of a test at full output in the high-pressure turbine which terminated after eighty-four hours when the compressor stalled owing to build-up of deposit in the high-pressure turbine. These tests were run with the low-pressure line cut out and a nozzle installed in the high-pressure turbine discharge corresponding to the back pressure developed by the low-pressure turbine. This simplified the running and reduced the amount of corrosion damage which might occur. That is why no figures for the low-pressure turbine appear in columns F and G of Table V.

Fig. 8 shows the condition of rotor and casing blading when opened up after the run of eighty-four hours.

The swallowing capacity of the turbine was measured by using the inlet flow parameter $G\sqrt{T}/P$ as a measure of change of area, where G=mass flow, T=absolute temperature, and P=absolute pressure.

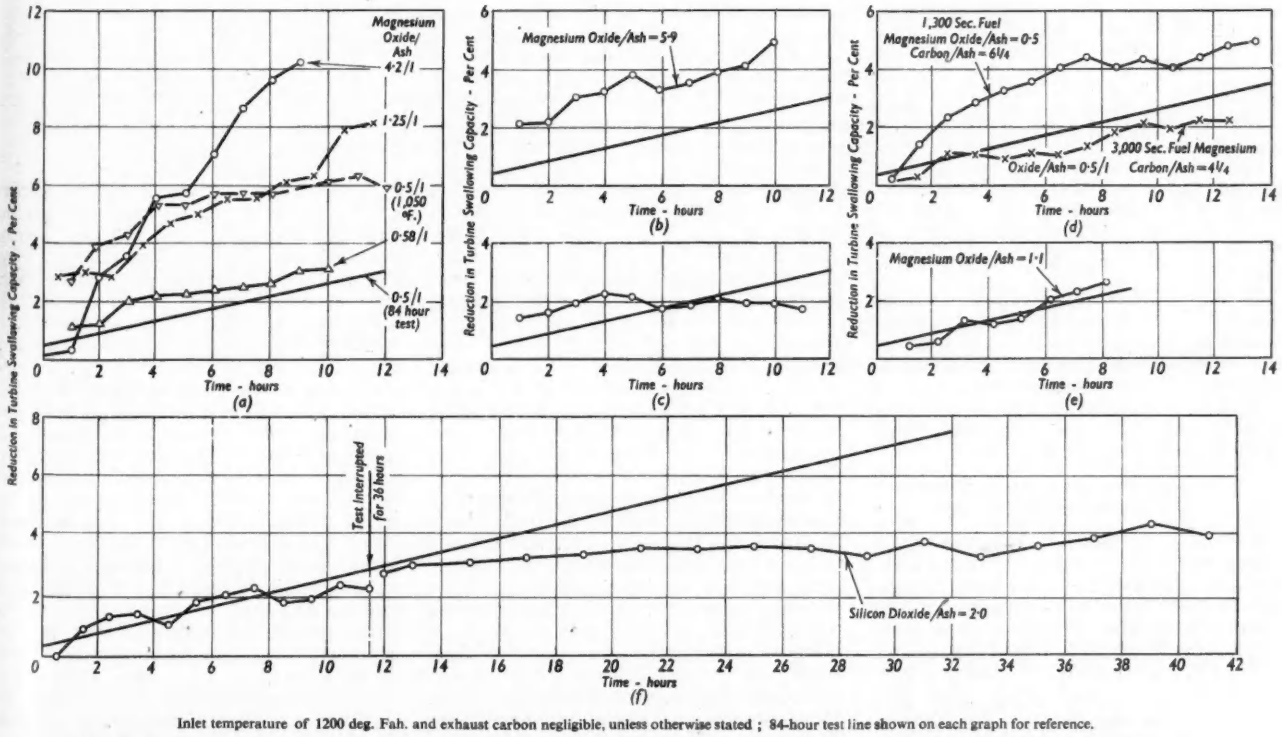
Owing to reduction in flow area through the turbine, the pressure ratio of the cycle is increased and the mass flow decreased. This causes the operating line on the compressors to move towards the surge line. Results of other runs with different additives are shown in Fig. 9, the full line in each instance being the eighty-four-hour run which was used as a means of comparison. By comparing the slopes of the curves it was possible to use shorter runs and decide early in the test whether the rate of build-up was better or worse than before. It will be seen from the lowest curve shown on this diagram that an additive has been found for which the build-up is quite bearable over long periods. The run on kerosene with an additive introduced was arranged in order to provide a sulphur-free fuel to determine whether sulphur affected fouling. It was found that it did. With all the additives mentioned, the turbine, when cold, was effectively cleaned between runs by washing with water.

For every ton of Mothball fuel burnt the ash content is 1·1 lb. If to this is added 2 lb or more of inhibitor, the amount of material to be handled by the turbine is trebled. If it sticks, the build-up is increased and, although corrosion attack may be stayed, the turbine is still not able to utilise residual oil. It is therefore necessary to produce solids which, while inhibiting corrosion, pass through the turbine without sticking or causing build-up in the subsequent components. Some experience with ethyl silicate as an additive appears to show that this requirement has been met. At lower temperatures sticking did not occur with other additives and the heat exchanger remained clean throughout.

Depression of the combustion to produce carbon was tried, but was unsuccessful. In vortex combustion chambers it has been possible to control combustion so that each droplet of oil continues to burn until only the minimum amount of carbon, with the ash content still undispersed, remains. With the straight-through combustion chamber it could not be achieved, and, in any event, this method would appear to be too critical for practical use. In such combustion chambers there are considerable losses caused by the presence of unburnt products in the gas as

TABLE VI—*Conditions of Runs*

A	B	C	D	E	F	G
Full load ... ... Gas oil fuel	Full load ... ... Gas oil fuel	90 per cent load... ... ... Gas oil fuel	90 per cent load... ... ... Gas oil fuel	60 per cent load... ... ... Gas oil fuel	Equivalent full load ... ... Residual fuel " Mothball " with magnesium acetate as additive	Equivalent full load ... ... Residual fuel " Mothball " with magnesium acetate as additive
Equal temperatures at inlet to high-pressure and low-pressure turbines	Equal temperatures at inlet to high-pressure and low-pressure turbines	Equal temperatures in high-pressure and low-pressure turbines	Higher temperature in high-pressure than low-pressure turbine	This is near maximum power obtainable without use of reheat combustion chambers	Low-pressure line out of operation. Beginning of run	Same run as F, nearly 84 hours later prior to high-pressure compressor stall which ended the run



Inlet temperature of 1200 deg. Fah. and exhaust carbon negligible, unless otherwise stated ; 84-hour test line shown on each graph for reference.

(*a*) Mothball plus magnesium acetate.
(*b*) Mothball plus magnesium sulphate (12 lb per ton).
(*c*) Kerosene plus magnesium sulphate (12 lb per ton).
(*d*) Heavy fuels plus magnesium acetate.
(*e*) Mothball plus magnesium carbonate.
(*f*) Mothball plus ethyl silicate.

Fig. 9—Fouling Tests on Gas Turbine of 3500 h.p.

long as some carbon from the fuel remains unburnt. It may appear that too much is made of the burning of residual fuels, but it —as well as the use of residual fuels in gas turbines—is the clue to the operation of high-temperature steam superheaters in boilers.

Cleaning of Compressors.—Throughout the extensive series of trials the low-pressure compressor remained clean. The industrial atmosphere at Wallsend was drawn through dry air filters and no trouble was experienced. In the high-pressure compressor some carry-over of water from the intercooler occurred and it was found that the dirt then baked on to the compressor blades. This dirt evidently did not stick until wet. A water separator at outlet from the intercooler improved matters. While running, the compressor was washed with water with 1 per cent Lissapol added, and this was effective in keeping the blading clean in the high-pressure compressor.

Corrosion of Heat Exchangers.—The heat exchanger was tubed with aluminium-bronze tubes and serious corrosion occurred even when distillate fuel which contained a normal quantity of sulphur was burnt. The mechanism of corrosion was found to be due to dewpoint deposition of sulphuric acid modified by the action of corrosion products which absorbed moisture under idle conditions. A change in materials will obviate this.

Although these details apply to a particular installation, it is believed that the problems mentioned are common to all. A solution for them must be found before the production of high-temperature turbines is undertaken. An investigation follows of the basis of the use of high temperatures in gas turbines up to an inlet temperature of 3000 deg. Fah.

Theoretical Investigation of High-Temperature Gas Turbine

The first consideration is the limit of gas temperature which a combustion chamber can withstand. In theory, a combustion temperature rise of 4000 deg. Fah. is possible, but the maximum attainable in practice will depend on the quality of refractory which can be obtained to line the chamber. The limit with present materials would appear to be 3500 deg. Fah. (1927 deg. Cent.). Incidentally, carbon has reasonable strength at high temperatures and success in providing an oxidation-resistant coating would greatly increase its temperature range, since carbon has a bend strength of 8000 lb per square inch at 3090 deg. Fah. (1700 deg. Cent.). Zircon is stronger but the low Young's modulus and high conductivity of carbon reduce the thermal stresses set up by thermal transients.

Cooling.—The extreme limit of temperature obtainable without cooling, even with alloys only available on a laboratory scale, is again 1500 deg. Fah. for long-life gas turbines. Any higher temperature at turbine inlet will involve cooling the metal parts to enable a life of 100,000 hours to be obtained. Among the methods of cooling are :—

(1) Air cooling directly through passages in nozzles and blades, and by shields fitted in the casing and at sides or discs.

(2) Effusion cooling by air flowing through porous sintered material from which blades, nozzles, shield rings, &c., would be formed. (Effusion cooling by water, i.e. sweat cooling, could not in general be considered, as the pores might choke up and the water loss could not be tolerated.)

(3) Water or other liquid cooling directly through the rotor and blades or indirectly by convection cooling in a closed circuit as shown in Fig. 10, which shows a Power Jets patent mentioned in a series of articles in *Engineering*, June, 1953. The work of Pametrada is being done under an Admiralty contract and security considerations prevent Pametrada's own configurations being shown. Convection cooling (which is well known as a principle) applies as shown to rotor blading in which a centrifugal field up to an equivalent value of 30,000 *g* can be generated. Stationary parts of a hot gas turbine would have to be protected by refractory with cooling behind this protection, or effusion-cooled shields and blades could be fitted.

Comparative figures for internal air cooling were worked out for a particular blade profile shown in Fig. 12. This is a reaction blade designed for inlet and outlet angles of flow of 30 deg. and 60 deg. measured relatively to the axial direction. The pitch/chord ratio is 0·7.

The velocity distribution round the blade was found by calculations based on Howell (1941), and Huppert and MacGregor (1949). The heat-transfer calculations were then made separately for the regions of laminar and turbulent flow for the effusion-cooled blade. The same blade profile was used for calculations on air cooling using the following configurations of the cooling passages within the blades :

(1) A hollow blade without insert ;

(2) A hollow blade with insert ;

(3) A hollow blade with internal cooling fins ;

(4) A blade with a large number of holes of small diameter such as is used in the air-cooled turbine of the National Gas Turbine Establishment (Ainley 1953) ;

(5) A blade having a smaller number of larger holes with inserts providing secondary cooling surface (Smith and Pearson, 1950).

In regard to these calculations on internal air cooling, it should be noted that the blade temperature increases from blade root to tip, the worst conditions for creep failure occurring in general part of the way up the blade.

A curve of permissible temperature, drawn to a base of blade height from root to tip, is first produced to give a chosen creep value corresponding to the designed life of the blading at the appropriate stress-value. The actual variation of blade temperature for given values of temperature of cooling air and gas, at a given Reynolds number for the gas and a given ratio between the weight of cooling air and gas, can then be found (Smith, 1948), blade conduction being neglected and constant heat-transfer rates being assumed along the blade.

For large cooling air flows this method is sufficiently accurate. For the more efficient designs ((4) and (5), Fig. 11), the variation along the blade of the heat-transfer coefficients is appreciable, and a step-by-step calculation was used in these instances. The results given in Fig. 11 show the progressive reduction in the amount of cooling air required in these five designs and, in fact, clearly indicate the limits of temperature for each type of cooling. Used beyond these limits the cooling air requirements cause a rapid loss in efficiency. It is doubtful whether any great improvement in cooling efficiency can be obtained over that of design (5) for cooling by air flowing radially through the blade. As the effectiveness of the cooling air passages is increased, less cooling air is required and the temperature rise of the air passing along the blade is increased. The increased cooling air temperature towards the tip causes the blade

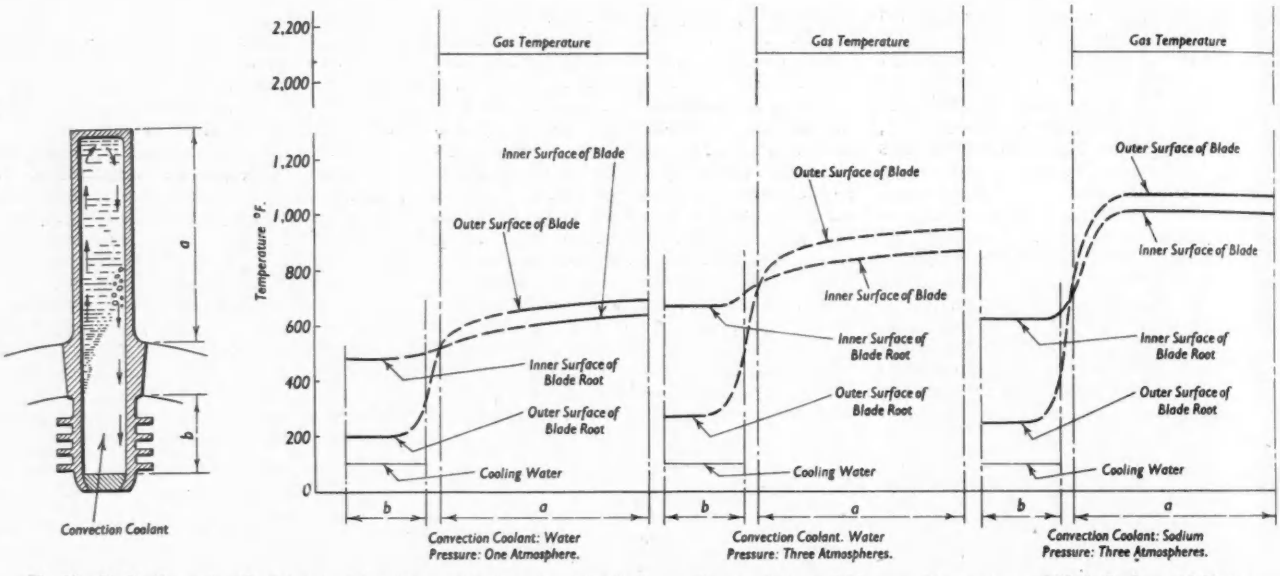


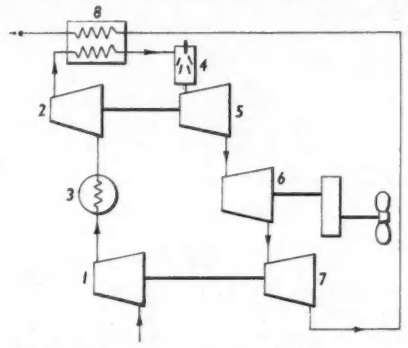
Fig. 10—(Left) Convection-Cooled Rotor Blade (Power Jets Patent). (Right) Curves Showing Estimated Change in Temperatures of Blade Surface with Various Convection-Cooling Fluids and Constant Gas Temperature of 2100 deg. Fah.

temperature there to approach the maximum permissible value. Any further improvement in effectiveness cannot bring about a further reduction in cooling air quantity since overheating would occur. This appears to be a fundamental limitation on internal air cooling.

Taking the most efficient form of air cooling on the rotor blades (effusion cooling) and using ceramic nozzles and lining of the casing the efficiency and air rate of the cycle shown in Fig. 13 are practically identical with those of the liquid-cooled gas turbine. It is, however, extremely doubtful whether given by Ainley (1953) fully substantiate the figures given here, since a peak aerodynamic efficiency of the stage of 79 per cent was obtained. In addition to cooling the rotor blading, cooling of nozzles, casing, rotor body, and other parts will be required. For air cooling thin metal shields spaced off from these more robust parts, which must be protected, are therefore necessary. Such construction tends to be flimsy, although it would be suitable for plant of short or medium life.

The low temperature and high heat capacity of water (in relation to air) make this the ideal medium to remove heat at a rate sufficient to enable the working parts of a marine gas turbine to develop the strength necessary for a long life. This would also lead to a robust design. As already shown, the main cooling passages can be large and should not penetrate any portion of the blade. The water in the cooling circuit in rotor and casing would, of course, be distilled, but the heat exchanger necessary to reject the heat to circulating water drawn from the sea would not be large. In more specially developed types of hot gas turbine the heat removed might generate low pressure steam. As the sealed coolant, for example, water, in the blade proper may even cool the blade too much at high centrifugal speeds, metals such as magnesium or aluminium may be used so that convection cooling of the rotor blades only begins when the blade temperature exceeds the melting point of the metal. New problems arise of intergranular attack of the high temperature alloys of which the blades are formed by, for example, molten aluminium, but again they are not insoluble. The metal temperature at the leading and trailing edges of the blade will be higher than the mean temperature, but even this is to some extent under control through modifications in the shape which are still acceptable according to aerodynamic considerations.

Fig. 10 shows the estimated metal temperatures for a particular design of convection-cooled blade with water or sodium in the sealed chamber inside the blade.

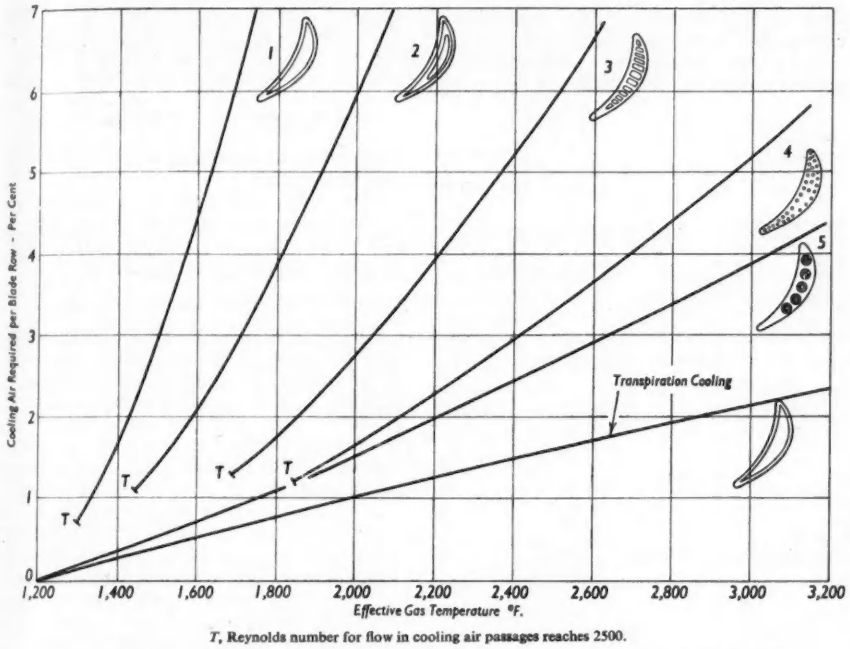


1. Low-pressure compressor.
2. High-pressure compressor.
3. Intercooler.
4. Combustion chamber.
5. High-pressure turbine.
6. Intermediate pressure turbine.
7. Low-pressure turbine.
8. Heat exchanger.

Fig. 13—Diagram of High-Temperature Gas Turbine Cycle

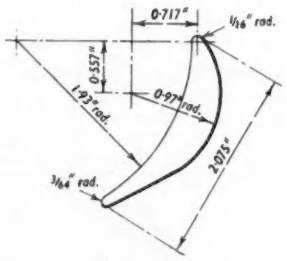
The calculations are performed for a gas temperature of 2100 deg. Fah. at a pressure of 1 atm. in the case of water. The change of temperature of the blade is then shown for water with the gas at a pressure of 3 atm. and a similar condition of gas with sodium as a coolant, the gas temperature being 2100 deg. Fah. A reduction in cooling loss would be obtained by choosing metals with higher melting points.

(To be continued)



T, Reynolds number for flow in cooling air passages reaches 2500.

Fig. 11—Estimated Weight of Cooling Air per Weight of Gas Required for Different Cooling Arrangements at Various Temperatures



Blade profile.

Blade temperature : (*a*) transpiration cooling, 1200 deg. Fah.; (*b*) internal cooling—to give the same life as for a blade with a uniform temperature of 1200 deg. Fah.

Cooling air inlet temperature, 120 deg. Fah.; blade aspect ratio, 2·5 ; pitch /chord ratio, 0·7 ; gas outlet angle, 60 deg. relative to axial direction ; $Re_{2,\rho} = \rho_2 u_2 c/\mu_2$, 2×10^5.

Fig. 12—Blade Profile and Relevant Details for Fig. 11

the stainless steel sintered compacts of which the effusion-cooled surface of the blades is formed can be produced with sufficient strength to operate as rotor blades. Therefore, some of the other types already described will be required and the efficiency will always be less than that for liquid cooling. In regard to air cooling—design (3), Fig. 11—a direct comparison has been made between a liquid-cooled turbine and an air-cooled turbine using finned blades in the rotor. The comparison, made at a temperature of 2200 deg. Fah. at turbine inlet, and a pressure ratio of 15, is shown in Table VII.

In these comparable figures between air and water cooling, the only change has been in the rotor blading. If the turbine had been wholly cooled by air, the figures would have been considerably worsened. Figures

TABLE VII—*Comparison Between a Liquid-Cooled and an Air-Cooled Turbine*

Type of rotor blade	Thermal efficiency, per cent		Air rate, lb per s.h.p.-hr	
	With heat exchange : 0·75 thermal ratio	Without heat exchange	With heat exchange : 0·75 thermal ratio	Without heat exchange
Air-cooled (design (3), Fig. 11)	37·8	31·1	16·0	15·3
Water-cooled...	40·9	32·3	15·3	14·7

Study of Vehicle Component Manufacture

REPRESENTATIVES from Austria, Belgium, France, Germany, Italy, the Netherlands and Norway have recently completed a study tour, under the sponsorship of the Organisation for European Economic Co-operation in the United States and the United Kingdom, during which they studied the various aspects of the manufacture, delivery and distribution of equipment and components for motor vehicles. A previous mission had drawn attention to the important part played by manufacturers of equipment and components as being one of the major factors affecting production of motor vehicles in the United States. Their recommendations in this respect resulted in the sending of the new mission.

Members of the Mission had full discussions with representatives of the motor vehicle industry. This enabled them to study such technical aspects of the relations between suppliers and manufacturers as research, design, testing, manufacture and inspection, commercial aspects including orders, time schedules, guarantees, delivery, payment and packaging and financial aspects. During their stay in the United Kingdom, members visited the works of leading vehicle and component manufacturers. The observations, conclusions and recommendations of the mission will supplement the recently published O.E.E.C. report on the motor vehicle industry in the United States drawn up by European motor vehicle manufacturers. Members were impressed by the increasing importance attached by motor vehicle manufacturers in the United Kingdom and the United States to manufacturers of equipment and components, and by the competitive spirit prevailing in the United States. All producers were prompted by the desire to make increasingly large quantities of constantly improved products at the lowest prices, while maintaining good wages.

Aircraft Hydraulic Test Rigs

By R. T. SEWELL*

No. I

The increased complexity of high-pressure hydraulic systems for modern aircraft has resulted in a new approach to the problems of testing. The method of test and the design and use of test rigs is discussed, with particular emphasis on the necessity of testing complete systems under fully representative conditions.

THE article is divided into three sections, dealing with the testing of individual hydraulic components, complete systems, and finally, specialised testing.

All new designs of hydraulic components and modifications to already existing designs are subjected to thorough tests to determine the hydraulic characteristics, such as pressure tightness, general functioning and flow losses, followed by endurance testing. With the increasing number of flying hours between overhauls required by aircraft operators, whether civil or military, the reliability of components is of paramount importance.

Tests for satisfactory performance of complete systems are made on large rigs which reproduce with the greatest possible accuracy the conditions obtained on the aircraft, such as sizes and lengths of piping, geometric layout of the components, and loads applied to the jacks operating the undercarriages and control surfaces. The design and construction of such rigs, although expensive, is fully justified by the excellent results obtained. Without such a rig, development and "trouble shooting" would have to be carried out on the prototype aircraft itself, considerably delaying the flight test programme.

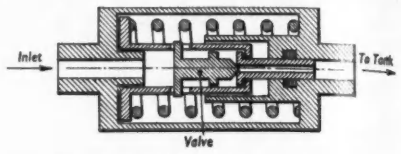


Fig. 3—Relief Valve. Schematic Diagram

Specialised testing includes climatic tests on components, and investigation into the behaviour of components and complete systems using electronic apparatus.

Review of Hydraulic Systems

The following brief review outlines the many new problems confronting those responsible for the hydraulics of the modern aircraft.

Figs. 1 and 2 show respectively the hydraulic line diagrams for a fighter used extensively in the last war, and a modern fighter. Table I will indicate the comparison in the number of services to be operated. The modern bomber is even more complex. However, the complexity of modern hydraulic circuits is not confined solely to aircraft. Fig. 4 shows the hydraulic line diagram of an American long-distance bus or coach. Individual components used in this circuit would have to be subjected to the same general tests which are applied to aircraft

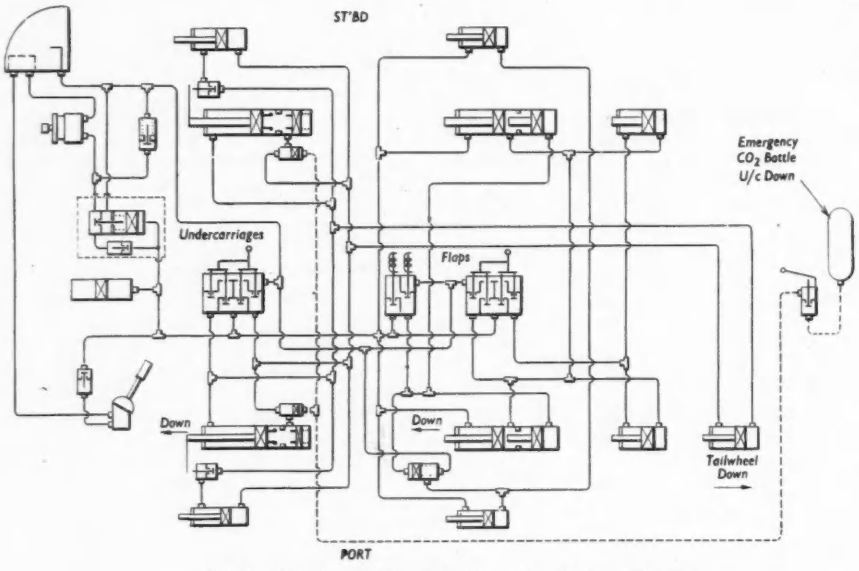


Fig. 1—War-time Fighter Aircraft. Hydraulic Line Diagram

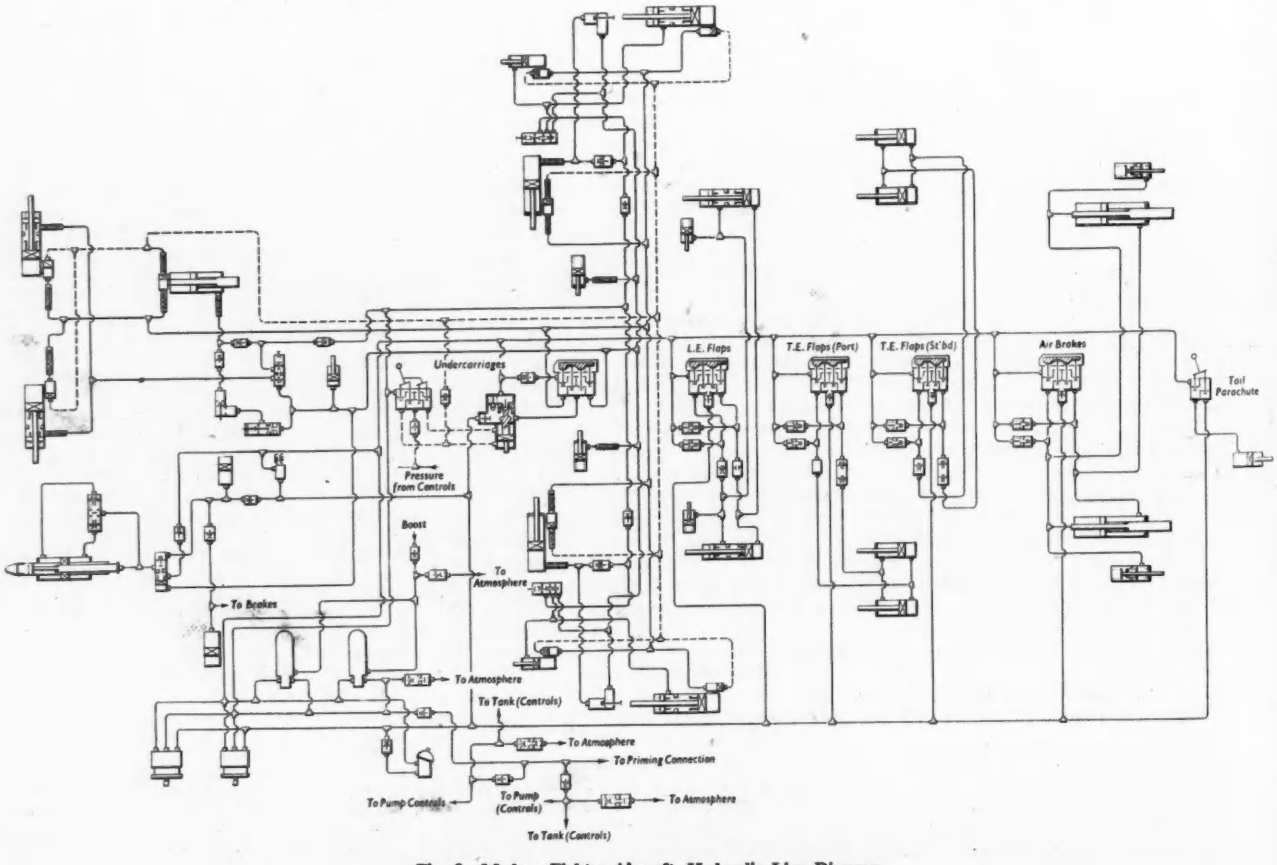


Fig. 2—Modern Fighter Aircraft. Hydraulic Line Diagram

* British Messier, Ltd., Gloucester.

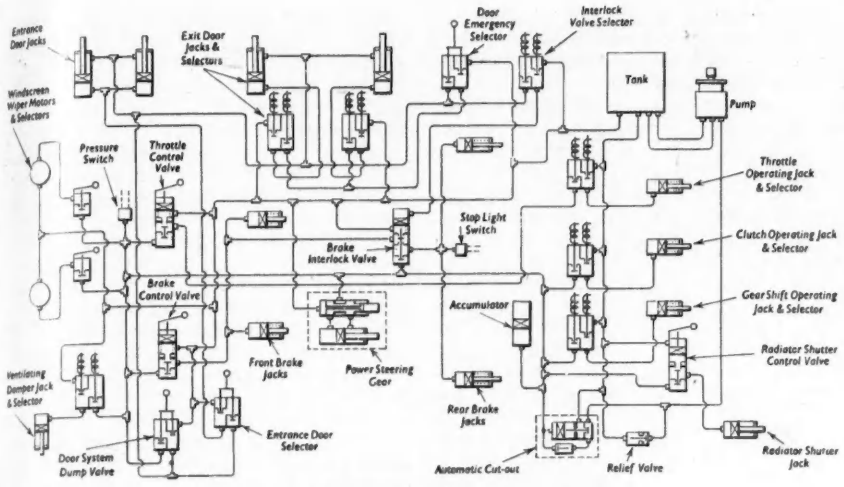


Fig. 4—American Bus. Hydraulic Line Diagram

components, and the complete system would need to be tested on a full-scale rig in the same manner as a complete aircraft system.

The all-up weight of a modern aircraft is practically twice that of any British war-time aircraft of a similar category. Speeds have increased greatly with the use of jet engines, resulting in new and larger control surfaces, some of which may have to operate very rapidly. The operational height may be up to 50,000ft, which lays increased emphasis upon satisfactory operation at extremely low temperatures.

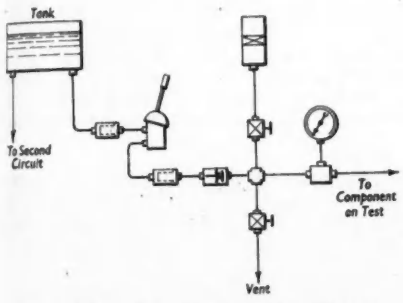


Fig. 5—Static Test. Hydraulic Line Diagram

Development Testing of Hydraulic Components

For the majority of components, a routine method of test has been established, which is adhered to as far as possible. A test schedule is drawn up indicating the general lines to be followed, taking into account the purpose for which the component was designed. A typical example will be given in Appendix I, referring to a relief valve, a schematic diagram of which is shown on Fig. 3. It should be realised, however, that subsequent development may result in considerable divergence from the original test schedule.

Certain components designed for one specific purpose require special equipment, and examples of this will be given.

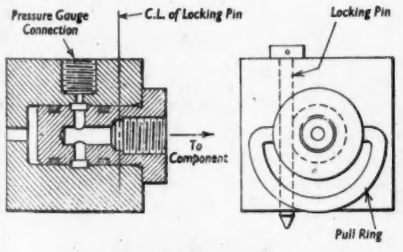


Fig. 6—Adaptor Block

The test rigs used will now be discussed in detail.

Static Testing.—A hydraulic static bench is the basic item of equipment in the laboratory, and on it are carried out all tests to determine pressure tightness and preliminary functional tests where no continuous flow of oil is required.

The bench need consist only of a suitable framework to support the oil tank and hydraulic components. A typical circuit diagram is shown in Fig. 5. The circuit consists of a hand pump drawing oil from the tank through a filter, and delivering at pressure through a second filter and non-return valve to a connection block embodying a pressure gauge. Pressure can be vented from the line by opening a screw-down cock teed-off from the main line. A small accumulator is included to give additional capacity and to provide a small flow of oil where required. A cock is provided to isolate the accumulator when not in use. It is an advantage to have two identical circuits on the bench, as certain components may require the simultaneous application of pressure at two separate points.

The component on test is directly connected to the block by means of push-in adaptors. A drawing of the block with an adaptor plug in position is shown on Fig. 6. The plugs are designed so that there are no out-of-balance hydraulic loads tending to blow them out. Axial rotation when tightening up the connection is prevented by the locking pin. A complete series of plugs is made with the tapping to suit every size of standard connection. Their use obviates the necessity of having to make and break joints every time the component is removed for examination.

For all normal tests, the hand pump should be capable of delivering oil at a pressure twice that of the normal system pressure (e.g. 4000 lb per square inch). For burst tests a special hand pump is needed which can attain not less than three times the normal system pressure. A typical hand pump is shown on Fig. 7. This pump can attain a pressure of 15,000 lb per square inch for a handle load of 50 lb.

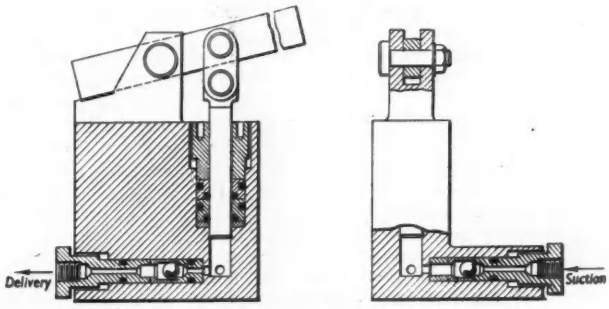


Fig. 7—High-Pressure Hand Pump

Additional connection blocks with adaptor plugs should be fixed to the bench to permit

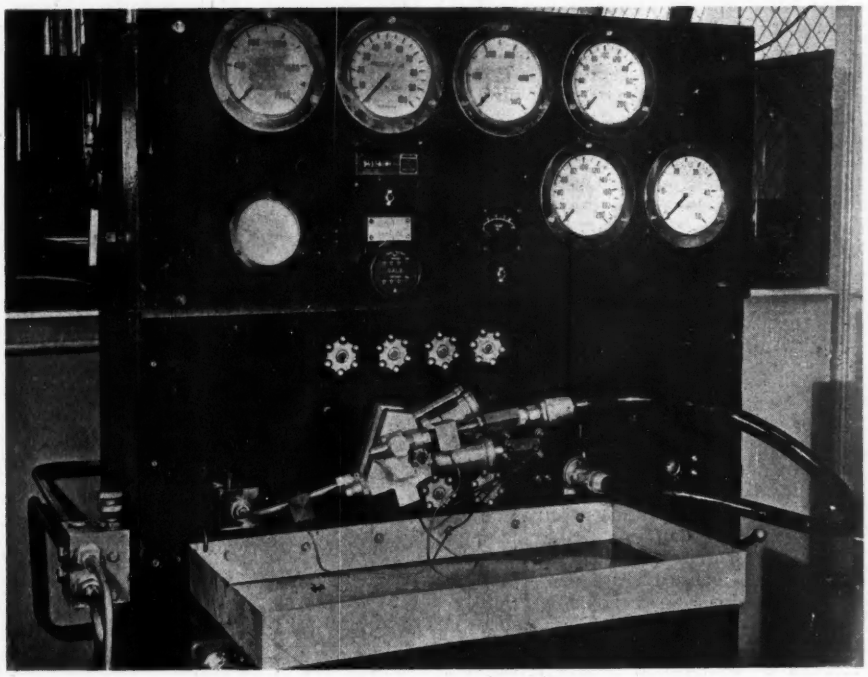


Fig. 8—Flow Test Rig. Control Panel

plugging-in of pipes leading from components—for example, when testing a selector which connects the inlet to a jack connection when a lever is depressed.

Benches on castors for easy transportation are useful, as it is sometimes more simple to take the bench to the job than the other way round. Separate benches are set aside for tests with special hydraulic fluids.

Flow Testing.—Great attention must be paid to the flow characteristics of hydraulic line components. Pressure loss curves should be obtained up to the maximum design rate of flow, plus 50 per cent to allow for contingencies. Such data are invaluable to the circuit designer when estimating line losses in a complete system, as excessive pressure loss may result in failure of the jack to operate in the required time under the most adverse loading conditions.

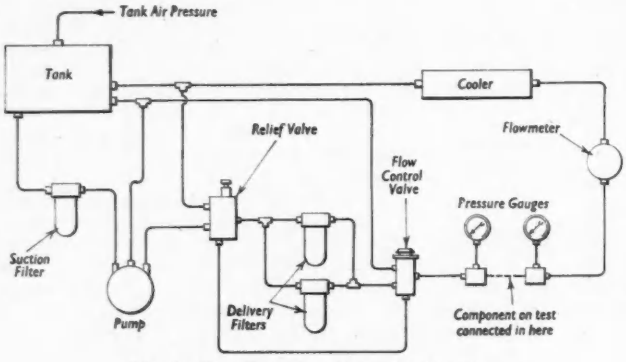


Fig. 9—Flow Test Rig. Hydraulic Line Diagram

In development testing the normal practice followed is to determine the characteristics of the component completely assembled, and then to repeat the test with the internal valves, springs, &c., removed one at a time. Any local source of restriction, a common fault with many new components, is then immediately obvious. Both normal and reverse flow conditions should be covered (some special types of valve have a tendency to close under conditions of reverse flow).

For practically all components under consideration a maximum rate of flow up to 120 cubic inches per second at a pressure not exceeding 1000 lb per square inch is sufficient. The relief valve referred to in " Static Tests " is a special case and will be dealt with later.

The control panel of a typical flow test rig is shown on Fig. 8, and the complete line diagram on Fig. 9. For reasons of clarity the line diagram shows only two gauges, whereas the photograph shows six. On the actual rig four gauges are connected to a manifold on the inlet side, and two gauges to a manifold on the outlet side. The inlet gauges cover the range up to 1000 lb per square inch, and the outlet gauges a range up to 200 lb per square inch. The gauges not in use are isolated by the cocks shown. Flow is obtained from a constant-displacement pump, controlling the rate of flow through the component by means of an infinitely-variable flow control valve. Alternatively, the flow control valve could be dispensed with and the pump driven by a variable-speed motor. The latter method suffers from the disadvantage that the speed ratios of suitable electric motors are not generally sufficient to cover the range of flow rates required, although an improvement can be effected by taking the drive through a four-speed gearbox.

Measurement of rate of flow is done on the tank return line after the oil has passed through the component. Many instruments are available for this purpose; personal preference will decide the choice.

A thermometer is included in the circuit, as for direct comparison of results the oil temperature should be constant. Some form of oil cooling is essential.

Several methods of measurement of pressure drop across the component are known, such as the differential gauge, and an apparatus using a piston in a cylinder, with each side of the piston connected before and after the component. The differential loads on the piston are balanced by a steelyard mechanism, the scale of which is graduated to indicate pressure drop across the component on test. The most simple, and probably most reliable method is to record the pressure drop by direct observation of two gauges, one on each side of the component. The author's experience of this may be of interest.

Originally, pressure recordings were taken at the blocks to which the component was connected by means of pipes. At the completion of the test these pipes were individually calibrated under the same conditions as in the main test, and corrections then applied to the first results. This method was laborious and not very accurate where the pipe losses were high in relation to the overall pressure drop.

The method since developed is to use special muff connections which are brazed on to the pipes, and fit right up against the component. A pipe to the pressure gauge is taken from the muff itself. The effect of the extremely short length of pipe between the component and the gauge tapping is negligible, and no corrections are applied. Care must be taken in the design of the muffs to eliminate the Venturi effect, which would adversely affect the recordings.

Relief valves, pressure-maintaining valves and reducing valves, &c., require flow tests at a much higher pressure than that obtainable on the type of rig described. For example, a relief valve used in a 4000 lb per square inch system will not normally be required to open until the input pressure has reached 4800 lb per square inch, and this pressure may rise to 5500 lb per square inch when the valve is passing the maximum design rate of flow. The basic design of a suitable rig does not differ greatly from the standard rig except in the source of hydraulic power. A lower maximum rate of flow is acceptable, of the order of 60 cubic inches per second at 5500 lb per square inch. Suitable industrial pumps are large and expensive, and it may prove more expedient to use a number of standard aircraft pumps. This also provides an interesting sideline on the behaviour of aircraft pumps by running them at this excess pressure.

A typical rig is shown on Fig. 10. The hydraulic power unit consists of four seven-cylinder swashplate aircraft pumps mounted on a gearbox with each pump driven from a common input shaft. The normal continuous rating of each pump is 4000 lb per square inch at 3600 r.p.m., but both pressure and

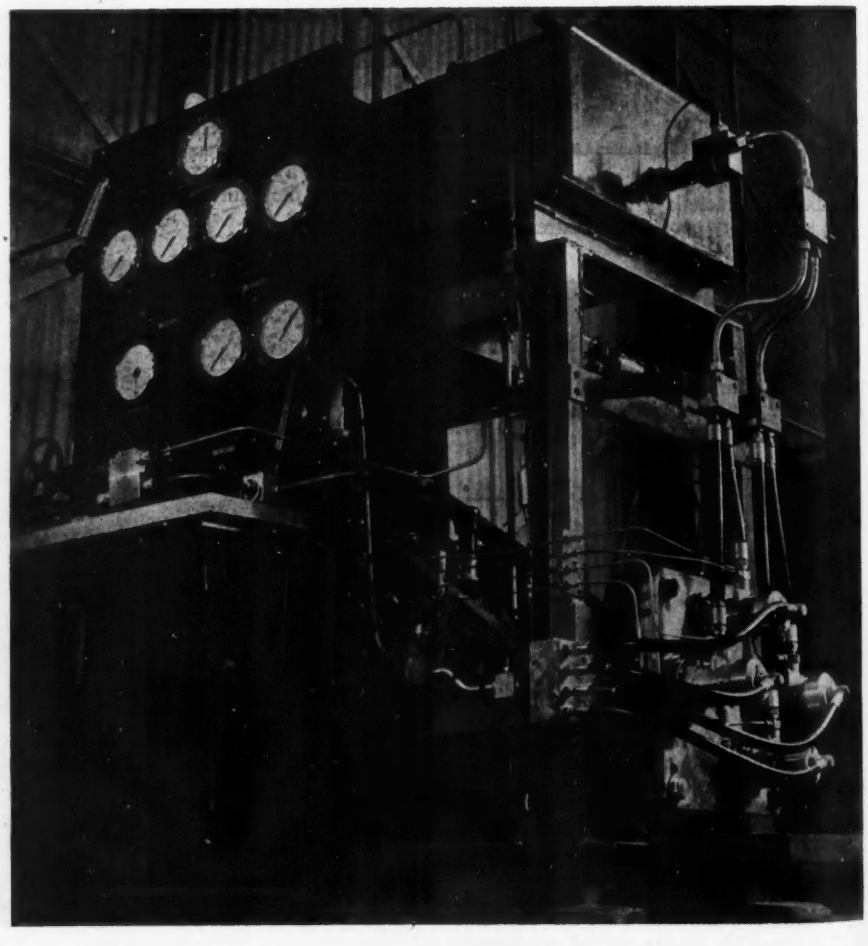


Fig. 10—Four-Pump Test Rig

speed may be exceeded for short periods. On this rig, the pumps are driven by a Ford V-8 engine through a standard four-speed gearbox. The rig has many other uses not connected with flow testing, such as functional and endurance tests on automatic cut-outs and selectors.

Flow tests may also be required during production tests on certain components in order to ensure satisfactory manufacturing standards. For such tests, a "spot check" at a fixed rate of flow is usually all that is necessary. A four-pump rig may again be used, except that the pumps are driven by a constant-speed motor, and four-step variation in flow rate is obtained by by-passing the flow from one to three pumps straight back to tank, isolation of the high-pressure and by-pass circuits being effected by non-return valves and cocks.

A smaller rig, generally similar to the first described may be used for flow tests with engine oil. The results of such tests will give an indication of the characteristics of components at low temperatures. For example, oil to specification DED.2472/D has approximately the same kinematic viscosity (380 centistokes) at normal room temperature as that of the standard aircraft oil DTD.585 at −40 deg. Cent.

(To be continued)

British Railways 2-10-0 Heavy Freight Locomotive

The first of a new type of 2–10–0 heavy freight locomotives has recently been completed at the Crewe works of British Railways. These locomotives with a tractive effort of 39,667 lb will be the most powerful two-cylinder engines in service in this country.

THE new rolling stock programme for the current year recently announced by British Railways stated that a number of the new class "9" heavy freight locomotives were to be built. The first of these new locomotives, which have a 2–10–0 wheel arrangement and are intended primarily for working mineral traffic, was recently completed at Crewe works. The design was carried out under the direction of Mr. R. A. Riddles, the former Railway Executive member for mechanical and electrical engineering, and a number of the details are common with those of other British Railways' standard types. Under the initial order twenty of the new locomotives are to be built. The main dimensions and weight distribution of the locomotive can be seen in the drawing we reproduce on this page and the leading particulars are given in the table herewith.

The wide firebox boiler is similar in many respects to that fitted to the standard locomotive classes "6" and 7." Owing to the need for placing the firebox above trailing pairs of coupled wheels of as great a diameter as 5ft, it was not possible to utilise an existing boiler. A new boiler has, therefore, been designed, which incorporates pressings made from the same press blocks as for the class "6," whilst the front tube plate uses the same pressing as that for the class "7." The firebox is, however, shallower than the 4–6–2 engines and, in addition, it has been necessary to employ a fire-grate which has the rear portion horizontal and the front portion sloping. The boiler shell is of high tensile steel plate, the barrel consisting of two rings, the rear ring being tapered. The plates from which the barrel rings are rolled are 19/32in and ⅝in thick, respectively, and the outside diameters are 5ft 9in at the front end and 6ft 1in where the barrel meets the firebox. The drumhead smokebox tube plate is ¾in thick and there are thirty-five large flue tubes 5½in diameter outside and 138 small tubes 2in diameter outside, the length between the tube plates being 15ft 3in.

Cylinders (two), diameter and stroke ...	20in by 28in
Wheels, coupled, diameter	5ft
Wheels, tender, diameter	3ft 3½in
Wheels, bogie, diameter	3ft
Wheelbase, coupled	21ft 8in
Wheelbase, engine	30ft 2in
Wheelbase, engine and tender	55ft 11in
Heating surface :	
Tubes	1,836 square feet
Firebox	179 square feet
Total evaporative	2,015 square feet
Superheater	535 square feet
Grate area	40·2 square feet
Boiler pressure	250 lb per square inch
Tractive effort	39,667 lb at 85 per cent boiler pressure
Adhesion factor	4·38
Weight of engine in working order ...	86 tons 14 cwt
Weight of engine and tender in working order	139 tons 4 cwt

The Belpaire firebox is 7ft 5½in long at the bottom, with a maximum outside width of just over 7ft, giving a grate area of 40·2 square feet. The throat plate is sloping and a combustion chamber is provided, whilst the back plate also slopes.

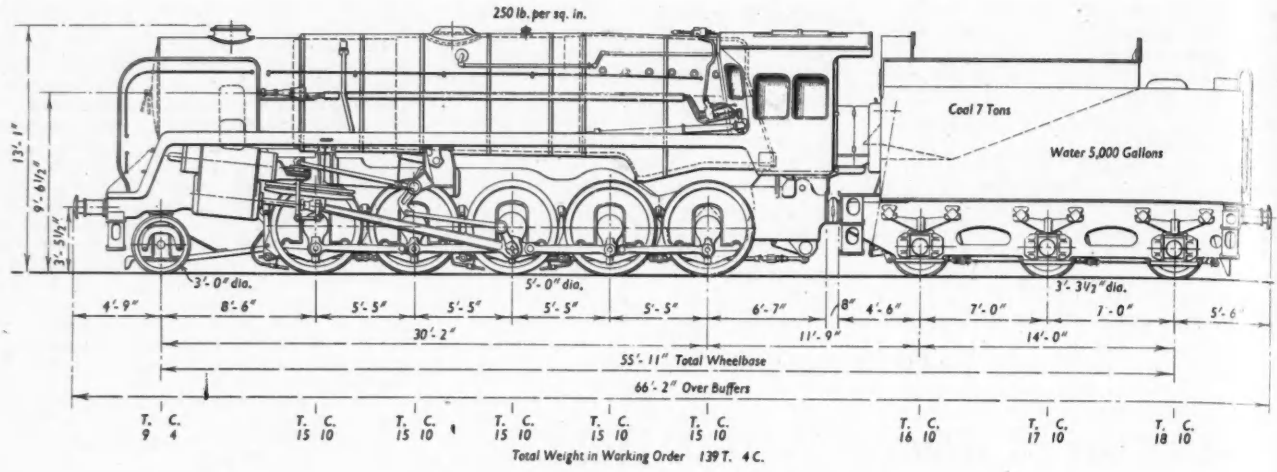
All the firebox water space stays, except those in the rows nearest to both the firebox back plate and throat and tube plates, are of Monel metal, fitted with steel nuts inside the firebox. The extreme rows are made of copper and riveted, in order to facilitate caulking of the joints between the plates. The roof, longitudinal and transverse stays, are of steel. On some of the locomotives the lagging of the boiler and firebox consists of "Fibreglass" mattresses, whilst others are being fitted with light weight asbestos mattresses.

The grate has twelve rocking sections, each fitted with twelve grid fire-bars. It is divided longitudinally so that the right-hand and left-hand sides can be rocked independently. The gear at the footplate is so arranged that full travel may be used for dropping the fire when standing over a pit, or a limited movement of the rocking sections made in order to break up clinker and eliminate ash whilst running. In the self-emptying ashpan to be seen in one of our illustrations, care has been taken to design the sides in such a way as to give the steepest possible angle from the outside edges of the wide firebox to the central hopper portion between the frames to assist clearance of the ash, as it will be appreciated that the ashpan has to be accommodated over the trailing pair of coupled wheels. Two hopper doors are provided at the base of the ashpan between the frames; and front and rear damper doors are fitted to regulate the air flow to the grate. These doors are controlled by handwheels in the cab which operate screwed spindles. Operation of the hopper doors is carried out at ground level using a removable key which also serves for working the rocking grate.

In the grid type regulator located in the dome the valves are arranged horizontally so as to be placed as high as possible in the very squat dome. The regulator operating gear enters the boiler transversely, passing through a stuffing-box on the side of the barrel. Its rodding from the cab is on the outside of the boiler and is divided into two lengths at a central rocking lever which compensates for relative thermal expansion.

The superheater has thirty-five ball joint elements of the Superheater Company's design, arranged in five rows of seven with a cast iron header. Two standard clack valves are arranged for top feed and are placed approximately at 30 deg. on either side of the vertical centre

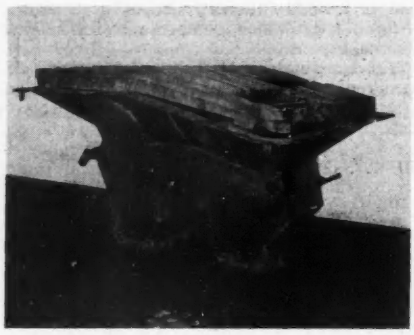
British Railways 2-10-0 Heavy Freight Locomotive



Arrangement of Two-Cylinder 2-10-0 Freight Locomotive

line, on the front barrel ring. They deliver the feed water on to two inclined deflectors which direct it around the barrel, clear of the tube bank. The steam manifold, incorporating separate shut-off valves to each auxiliary steam supply, is mounted on the top of the firebox outside the cab. This manifold forms the mounting for the whistle valve which is operated by means of a Bowden cable. The steam manifold can be isolated by means of a main stop valve, the handle for which is brought through into the cab, and this valve when closed cuts off the steam to all the auxiliaries, except the boiler pressure gauge. Two standard water gauges are fitted on the firebox backplate. Two Ross "Pop" safety valves are mounted on a recessed seating on the top of the rear barrel ring just behind the dome.

A cylindrical smokebox rolled from ⅜in thick steel plate rests on a fabricated saddle which also forms a rigid stay between the two outside cylinders, as can be seen in one of the illustrations. Self-cleaning apparatus is provided, consisting of a nearly vertical plate in front of



Ashpan and Rocking Grate

the tubes and a horizontal table plate so arranged as to conduct the gases downwards and to the front of the smokebox. A wire gauze screen placed across the gas passage to the chimney prevents the emission of large particles of unburnt fuel. The blast pipe has a single exhaust nozzle of 5⅜in diameter and four "Cardew" blower nozzles are incorporated in the cap.

The heavy, rigid frames of this locomotive consist of 1¼in thick frame plates spaced by vertical stretchers at intervals throughout the length. Horizontal plate stretchers extend rearwards from the saddle, continuously to the ashpan at a level just above the horn spaces, whilst at the bottom of the frame rigid cross stretchers are formed integrally with the vertical stretchers. The frame plates are located in the planes of the centre lines of the axleboxes. The welded-in hornblocks, which are symmetrical and are of horseshoe form, are provided with manganese steel liners on the guide faces. The bottom edges of the frame-plates are stiffened by means of steel castings of inverted "T" form, which are cast integrally with the spring hanger brackets and contain the registers for the hornstays. These castings are riveted to the frame by means of the same rivets which engage the lower cross stretchers. When the hornstays are in position the frame plates have what is virtually a continuous bottom flange. Between the fourth and fifth pairs of coupled wheels and over the horn gap for the latter the frame has to be cut away to clear the firebox, and to retain adequate strength as a beam at this point stiffening plates are riveted to each side of the main frame plates.

The dragbox at the rear end of the locomotive is fabricated and the coupling to the tender is by means of a drawbar having plain eye ends, the end in the engine having an elongated hole. Central curved rubbing blocks are provided on both engine and tender and under normal conditions these run ¼in apart. Two spring-loaded buffers are fitted to the tender dragbox and press against flat rubbing plates on the engine dragbeam.

The boiler is carried on the frames by a saddle fitted to a cross stretcher close to the front tube plate. At the back end expansion blocks, fitted to extensions integral with the foundation ring, rest on suitable frame stretchers at both ends of the firebox. The footplating along the sides of the boiler is carried on brackets fitted to the boiler shell by means of studs and, further forward, on brackets fitted to the smokebox.

Plain bearing axleboxes are employed throughout the engine. The coupled wheel axleboxes are steel castings, with tight-fitting steel keeps at the bottom to maintain parallelism of the manganese steel lined guide faces. The bearing consists of a pressed-in horseshoe brass lined with white metal. An oil tray bolted to the keep under the journal contains a worsted pad, to distribute the lubricant, oil being fed to the tray from a mechanical lubricator. The pony truck axleboxes are white-metalled bronze castings and are not mechanically fed with lubricant. Laminated coupled wheel bearing springs are fitted throughout, and rectangular tension spring hangers having cotters for adjustment are provided.

The two outside cylinders are steel castings fitted with cast iron liners to the steam chest and cylinder barrel. The piston valves have a nominal diameter of 11in are driven by Walschaerts valve gear giving a maximum travel in full forward gear (78 per cent cut-off) of 7⅞in with a steam lap of 1 11/16in and a lead of ¼in. The piston heads on the first locomotives to be turned out are of the box pattern made as a steel casting and fitted with two rings and a bronze spring-loaded slipper, designed to carry the weight of the piston and minimise wear between the piston head and the cylinder barrel. Later engines will have a light forged steel piston head which will be flash-butt welded to the piston rod. Three-bar slidebars are

Locomotive Under Construction with the Boiler Mounted on the Frame

provided in conjunction with an underhung crosshead.

Lubrication of the cylinders and piston valves is by means of atomised oil fed from a mechanical lubricator. This lubricator also feeds the piston rod packing and the valve spindle rear bush. The valve gear is lubricated mainly by grease and consists of plain bearing joints, except in the case of the return crank which is provided with self-aligning ball bearings. The reversing gear consists of a screw located at the reversing shaft with the nut acting directly upon the reversing shaft arm. A tubular shaft connects the screw to the hand wheel in the cab, which is of the end-on type driving through bevel gearing. The cylinder cocks are steam operated.

The five pairs of driving wheels are 5ft in diameter and the tyres are secured to the cast steel centres by " Gibson " rings. The balancing follows a principle not previously employed in this country, in which the rotating masses are fully balanced in the normal way but the reciprocating masses are statically balanced to the equivalent of 40 per cent, by placing lead weights in the coupled wheels in the same phase on both sides of the engine. This leaves the fore-and-aft balance of the locomotive the same as if the normal procedure were followed, namely, of making the reciprocating mass balance coincide with the rotating mass balance ; but there remains an unbalanced couple which, however, is no larger than that tolerated in three cylinder locomotives without reciprocating balance. The new system has an advantage in that it reduces the " wheel " hammer blow (but not the " axle " hammer blow) and also saves approximately 2 cwt of balance weight. The weights themselves consist of plates clamped on each side of the coupled wheel spokes to form pockets into which lead is inserted.

Steam sanding is provided to the leading and driving coupled wheels for running in the forward direction, and to the driving wheels only for reverse running.

The pony truck, with 3ft diameter wheels, is generally of similar design to that used on the other standard locomotives. It has helical bearing springs in two nests, each nest consisting of two springs, one within the other, arranged on either side of each axlebox. The load is transmitted to the axlebox by means of a yoke and shoe. Side movement is controlled by double helical springs, and a spring-loaded frictional retarding gear acts upon the front and rear faces of the truck centre to damp out oscillation and assist the locomotive in negotiating diamond crossings.

Cab and Tender

The cab follows the same general layout as that used on the other standard tender locomotives. It is supported on a fabricated platform which is bolted to the main frames, and includes the pedestal which carries the brake valve, blower and sanding valves, &c. Unlike the earlier standard designs, in which the whole of the footplate was on the engine, fall plates have been reintroduced and these are hinged from the front of the tender to rest upon the rearward extension of the cab floor. Gangway doors are fitted between engine and tender. All the driving controls are grouped to give easy access from the driving position, which is on the left-hand side. Seats with back rests are provided for both driver and fireman, and hinged side wind-screens are fitted on the outside of both sides of the cab.

One live steam and one exhaust steam injector are fitted to the right-hand side of the locomotive and are attached to a bracket carried off the frame, below the cab. The steam and water controls for these injectors are grouped within easy reach of the fireman.

Various arrangements of the tender will be fitted to suit the particular operating requirements of the region upon which the batches of locomotives are to work. Some regions require a high water capacity in relation to coal, particularly for routes where water troughs are infrequent or wholly absent, whilst elsewhere, for long distance freight work, where troughs are provided at frequent intervals, high coal capacity becomes the important factor. To meet these requirements, a new design of tender has been produced, in which the coal bunker extends to the full width of the water tank. The first tenders, however, will be of the existing pattern, having the narrow coal bunker.

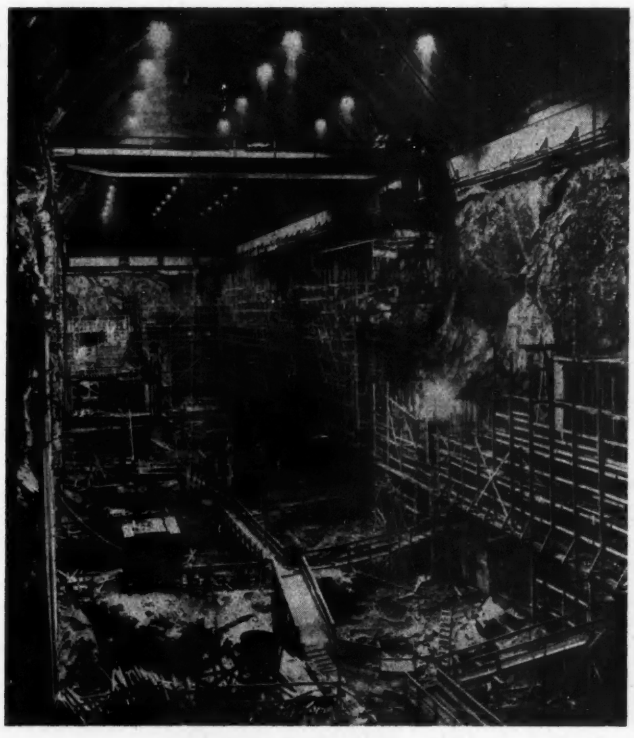
All the tenders have six 3ft 3½in diameter wheels and their axles are provided with British Timken roller bearing axleboxes placed outside the wheels. External feed water sieve boxes are fitted on each side of the tender to collect any particles of foreign matter which might otherwise be detrimental to the operation of the injectors. The sieves can be withdrawn for cleaning without the necessity for emptying the tank.

Steam brakes are provided on both engine and tender, and may be operated either directly by means of a steam brake valve, or in conjunction with the vacuum brake. The coupled and tender wheels are braked by means of a single block on each wheel.

Some Foreign Civil Engineering Schemes of 1953

No. II—(*Concluded from page* 132, *January* 22*nd*)

INDUSTRIAL expansion in Canada has been the stimulus for a number of ambitious civil engineering schemes undertaken in that country during the past few years, not least amongst which are the hydro-electric developments which supply a large part of the nation's requirements for power. In our corresponding article last year, we briefly noted the extent of new construction, and also gave some details of the progress of the new power station at Niagara Falls, the Sir Adam Beck No. 2 generating station, which will have an installed capacity of 900MW when complete. A second Canadian scheme, of even larger ultimate installed capacity —the Nechako-Kemano scheme in British Columbia—made good progress during 1953, and received a good deal of publicity. The scheme forms part of a major development project for the refining of aluminium ; an aluminium reduction plant is being built at Kitimat, and a new town and harbour created to serve the new industry. Electrical power will be supplied to Kitimat from the Kemano power station.



Construction of Kemano Power Station, British Columbia

Basically, the scheme consists of a rock-fill dam at Nechako, which raises the level of a natural basin comprising a number of lakes covering a vast area and having a natural outfall at Nechako, and then a diversion through the watershed at the other end of the basin to the Kemano River, which yields a gross head of 2585ft for the generation of power at Kemano power station. The ultimate installed capacity of the scheme will be about 1680MW, but it is planned to finish the first stage only during this year with three similar four-nozzle Pelton wheel sets installed totalling 314MW and operating at 327 r.p.m. The scheme is of particular interest on account of its size, for it is rivalled in its ultimate power production and in the size of the principal generating sets by few other hydro-electric schemes, and also because of the design of the diversion works and power station, which follow Continental rather than North American practice. The power station is excavated from the solid rock, and supplied by two penstocks also excavated from the rock and lined with a steel membrane backed with concrete, so that the strength of the rock itself is utilised to resist the pressure in the penstocks. Many examples of this construction can be found in Europe, but the Kemano design appears to be the most ambitious. For the first half of the power station — eight units totalling 840MW—two 11ft diameter penstocks are to be provided, so that each will have a capacity of about 550,000 h.p. The rock through which these penstocks pass was tested by excavating a test sphere, lining it as for the penstocks, and measuring pressures in the sphere and corresponding deformations, so that the modulus of elasticity of the rock could be determined during the tests. The accompanying illustration shows work in progress in the machine hall of the underground power station, which, in the present stage of construction, was excavated to a size sufficient for the installation of eight turbo-alternator sets, or half the ultimate installation proposed. Its size is about 1000ft long by 180ft wide by 135ft high. A further description of the scheme was given in The Engineer of May 29 and June 5, 1953.

European Hydro-Electric Schemes

An international survey of European water power resources was published by the United Nation's Economic Commission for Europe in 1953 (see The Engineer, July 10, 1953). The survey estimated that a total yearly production of 514,000 million kWh (Iceland and the U.S.S.R. are excluded from the report) was accepted as economically possible, of which 26 per cent had been developed by December, 1952, but to a

Sambuco Dam in Southern Switzerland

widely varying degree in different countries. Italy, for instance, the survey noted, had already exploited half of her known water power potential of 50,000 million kWh annually. Yugoslavia, with similar hydro-electric potentialities, had developed only 2 or 3 per cent. Improved knowledge of the extent of natural power was called for in the survey, and it was pointed out that the estimated figures of economically available resources might perhaps be somewhat conservative.

During the past two or three years we have published in this journal various articles describing present-day hydro-electric practice on the Continent, principally in France and in Italy. European hydro-electric construction during 1953 will therefore be exemplified in this review by only two projects, both of them in Switzerland. Our illustration above shows the construction of Sambuco dam in progress. This dam is to be an arch-gravity structure, with a maximum height of 130m. It will form the storage reservoir at the head of a system of three power stations on the Maggia River, which flows into Lake Maggiore close to Locarno. The lowest power station of the series—Verbano—discharges into the lake (all three are underground power stations) and is the base load station of the scheme, with an installed capacity of about 100MW in four similar Francis turbine sets. It went into full operation in 1953, but the upper works were not so advanced, and will not be completed until 1955. The total installed capacity of the scheme will be about 200MW, and the annual output nearly 800 million kWh, nearly half of which will be winter power.

Sambuco dam is in keeping with the Swiss trend of dam construction in which rather massive cross sections are generally favoured, in contrast to the slender arch dams of Italy and France. The base width of the dam is 69m, corresponding to the height of 130m, and the length and width at the crown are respectively 340m and 8m ; the crown radius is 200m and the volume of the dam about 770,000 cubic metres. Our illustration shows the progress made on the dam by last August. The concrete is placed in blocks 25m wide, and is cooled by water circulating in pipes laid on the surface of each lift ; these pipes may be observed in the illustration. The blocks are concreted, butting one against the next, and the joints are grouted when the concrete temperature falls to 10 deg. Cent. Concrete is placed by cableways spanning the site, and the constructional plant allows a maximum rate of concreting of 2000 cubic metres daily.

One of the smaller Swiss schemes, but nevertheless one not without interest, is the low-head development on the River Aare, between the towns of Wildegg and Brugg, from which it takes its name. The power station and part of the head race canal of the scheme, which was substantially completed in 1953, are shown in the illustration below. Utilisation of the Aare, below the older Rupperswil-Auenstein scheme, is effected by this new development, to give an annual power output of about 300 million kWh (55 per cent in the summer) from an installed capacity of 46MW. The principal machines in the power station consist of two similar Kaplan turbo-alternator sets, operating at a fairly high load factor under a gross head of 14·75m, rated at 23MW each at 115 r.p.m. and 175 cumecs. The head is formed by a barrage across the Aare, with a diversion canal some 4·5km in length on the left bank, with the power station about halfway along it.

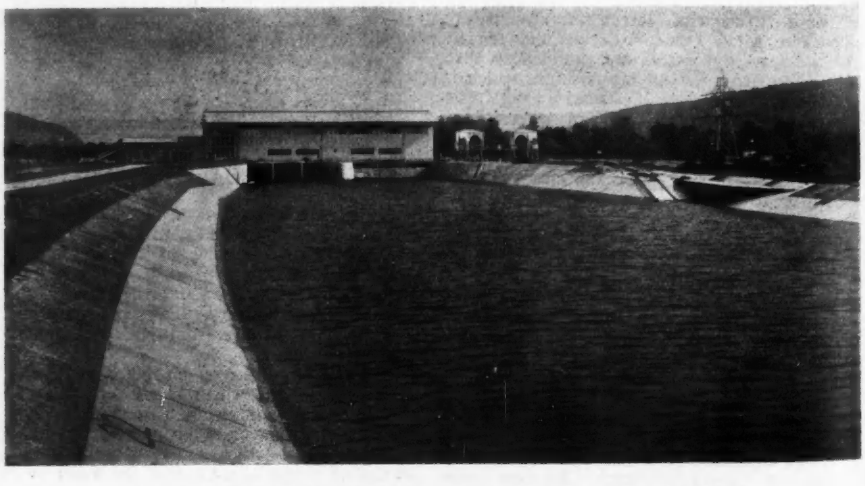
The scheme has been built in a well-developed area, and it had to avoid, as far as possible, disrupting existing amenities. One local asset made a great difference to the scheme—there are thermal springs on the right bank of the river, just below the barrage, which are widely used for their medicinal properties. It was stipulated that the scheme should not alter the natural water table in the vicinity of the springs, and for this reason the head race canal was lined with concrete, and a subsidiary barrage was built on the Aare, below the principal one, and below the springs, so as to retain the natural level of the river over the critical length next to them.

The scheme has entailed the construction of several new bridges, including a welded steel road bridge of three spans, and a prestressed concrete footbridge, both of attractive appearance. The principal barrage consists of four 15m bays closed by sector gates. A subsidiary generating set—a 650kW Kaplan turbine and alternator—has been installed at the barrage, to operate under the maximum head of 7·4m available there, utilising the 10 cumecs flow of compensation water passed down the river, for generating power for the station auxiliaries and operating the barrage gates. The scheme includes fish passes at the two barrages and the power station, and a slipway for hauling small boats past the power station has been constructed.

The Colombo Plan

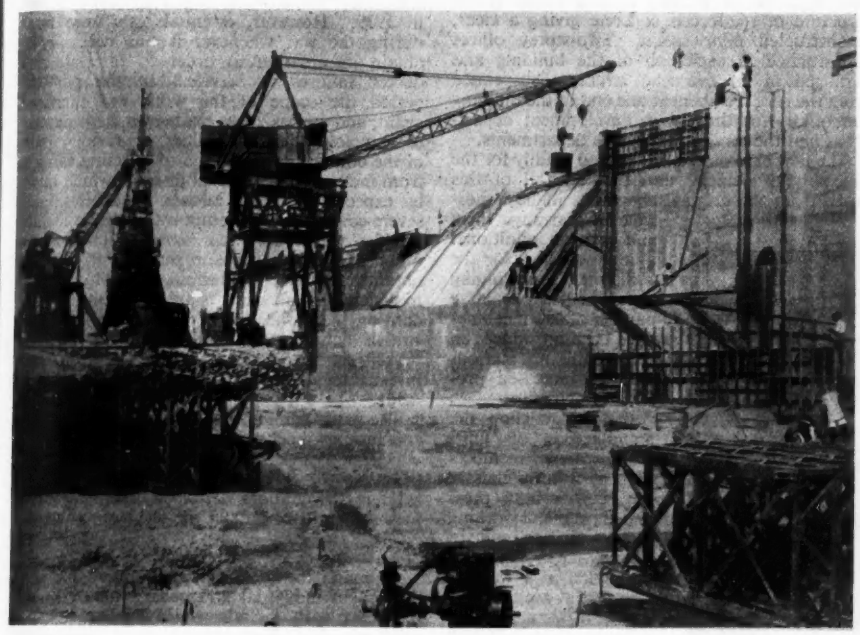
The attempt which is being made in South-East Asia to improve the living standards of the inhabitants of various countries in that region is of immense interest to the civil engineer. The Colombo Plan, as it is called, envisages the industrial and agricultural development of those countries with the co-operation and assistance of the more highly industrialised nations, such as Great Britain, Canada and Australia, and the United States. Last October a report on the progress of the plan was reviewed in a leading article in this journal (The Engineer, October 16, 1953), in which we noted that some £450 million had already been committed under the plan at that date. The importance of large water conservation projects in the plan can hardly be overestimated and although a proportion of the credit has been spent on immediately necessary food supplies, and on the import of machinery such as agricultural machinery, the long-term benefits of the plan are based on major civil engineering projects for the control of rivers and, hence, for irrigation and for the generation of power.

In India such projects have been grouped into a five-year plan which was described in our issue of January 23, 1953. Of the many water control schemes under construction, the largest ones are the Bhakra-Nangal scheme in the Punjab (described in The Engineer of August 10, 1951), the group of schemes in the Damodar Valley in Bihar, and the Hirakud project. Hirakud dam is under construction on the Mahanadi River, in Orissa State, and the dam and its associated dykes, power-house and canal system form the first and major stage in an integrated scheme for the development of the Mahanadi Valley. The dam will have a total length of nearly 16,000ft, nearly 4000ft of which



Power Station of the Wildegg-Brugg Scheme on the River Aare, Switzerland

is to be a concrete gravity structure, and the remainder an earth-fill embankment, the maximum heights of these two sections being 167ft and 195ft respectively. In addition, there is to be almost 68,000ft of subsidiary earth-fill embankment dykes, and spillway sluices and provision for a lock are to be incorporated in the concrete structures. The reservoir will have a useful storage capacity of 4,500,000 acre-feet, and owing to the hydrological behaviour of the catchment, it is thought that all the useful capacity will be available each year for irrigation and power generation, the reservoir being filled after the autumn floods. The area commanded for irrigation is nearly 2,000,000 acres, and the ultimate installation of generating sets in the power station will be 235·5MW, of which 123MW will be firm power. The constructional programme aims at completion of the main dam in 1956, as well as four turbo-alternator sets in operation in the power station, and completion of the left bank (Sambalpur) canal system.



Construction of Flank Wall of Hirakud Dam, India

The completion date for the Hirakud project is set at 1961, with the other smaller schemes in the Mahanadi Valley to be completed by 1971. The illustration herewith shows construction of part of the concrete dam in progress.

Sea Defences in Holland

The principal topic which we recorded in our annual review of civil engineering works in Great Britain in 1953 was the great achievement of reconstruction along the East Coast, following the storm and tidal surge of January 31st and February 1st last. A similar, but perhaps even greater effort was made throughout the year in the repair of breached and damaged dykes in Holland. The disaster in that country was even greater than on our own coasts ; 1783 people were drowned, and 100,000 had to be evacuated, 500,000 acres of land were flooded, more than half of it for a considerable time, and there was severe damage to property and livestock.

Many of the breaches in the damaged dykes were restored remarkably quickly, for in the experience of Dutch engineers very prompt repair by some improvised method often prevents the development of much more serious damage. The worst kind of breach was one where a considerable low-lying area behind it flooded and emptied at each tide, thus causing severe scour at the breach. Several large breaches of this nature were the last to be closed.

The most dangerous breaches were made in the sea walls of the Hollandse Ijssel, north-east of Rotterdam, one of them 25ft in width and a second of 150ft. If they had been allowed to develop the central parts of Holland between Rotterdam and Amsterdam would have been flooded—the lowest and most dangerous part of the country. These two breaches were, however, closed on Sunday, February 1st. Ships were sunk in the breaches and the remaining clay formation held for a few hours at low water, allowing sandbags to be placed to seal off the breaches.

The major breaches which could not be closed immediately necessitated large-scale civil engineering works for their eventual repair. One instance of such works occurred in the Kruiningen polder between the eastern and western Scheldt in the Zeeland estuary. Three breaches were made in the western side, one of them in an outer dyke of a harbour. An existing subsidiary dyke was first repaired, thus dividing the flooded area into two, and reducing the tidal flow through the main breaches and enabling two of them to be closed. The last major breach, in the harbour dyke, was closed by sinking concrete caissons—which were made and used for the " Mulberry " harbours in Normandy in 1944. Two caissons were first sunk, founded on willow mattresses, one on each side of the breach. The third caisson was placed between the other two to close the breach. It had to be placed in about ten minutes at the turn of the ebb tide, and was manœuvred into position above the willow mattresses by seven tugs. When repair is complete, the caissons will be removed.

One of the largest breaches was at Schelphoek, where a polder 24,000 acres in extent was flooded by a breach 525m wide. A large " horseshoe " dyke, 4km in length, was constructed clear of the gullies formed by the breach, but first the gullies were closed by " Mulberry " caissons. The two final lengths of the " horseshoe " were closed by placing 200 concrete caissons, each 11m by 7·5m in size, and filling them with sand immediately they were in position, against a head, at ebb tide, of nearly 3ft.

As an example of breaches where extensive repair work was necessary, but not work against tidal flooding, the extensive construction on the island of Goeree-Overflakkee may be noted. Here 25km of dyke had to be repaired in five months. Sand fill was placed hydraulically between retaining walls, and then bulldozed to the required profile. Enough sand was pumped into position to build 200m of dyke in a day. After bulldozing the sand was protected by a layer of bituminised sand consisting of 8 per cent bitumen, 8 per cent filler and 84 per cent sand, placed 40cm thick at the base and 10cm thick at the top of the dyke. A sealing layer of asphalt, 10cm thick, is to be placed over it, at the top of the dyke, and the seaward slope protected by an asphaltic sealing layer. The inner slope is covered with clay and turfed. This method was considered to be the only practicable one to use in the time available for 22km of the 25km of dykes. The conventional clay and stone sett construction was employed for the remaining 3km. About 300,000 tons of asphaltic mixtures were used on this work.

Metallurgical Aspects of High-Temperature Steam and Gas Turbine Plants

On January 15th a paper entitled " Metallurgical Aspects of High-Temperature Steam and Gas Turbine Plants " was presented before the North-East Coast Institution of Engineers and Shipbuilders by J. M. Robertson, D.Sc., Ph.D., A.R.T.C., and is summarised below.

High temperature in connection with metals is defined and 800 deg. Fah. mentioned as being the dividing point between the range of ordinary and high temperatures for mild steel. For the construction of high-temperature turbine plants a wide range of alloys is available and in order to make a selection from them for component manufacture, information about their mechanical behaviour under widely different conditions is an essential. The paper goes on to discuss the properties of high-temperature materials, referring to the phenomenon of creep and stating a criterion in common use in turbine engineering component design. Extrapolation of creep data is considered and two methods are outlined and then, following notes upon creep and ductility, the creep properties of different materials are discussed.

The problem of high-temperature fatigue is generally reviewed and reference made to relaxation tests which imitate conditions under which stress changes with time while strain remains constant as compared with conditions of constant stress and changing strain under which creep tests are carried out. It is mentioned that temperature gradients throughout the plant set up static thermal stresses and that fracture resulting from a number of thermal cycles is known as thermal shock while the same result from a large number of cycles is due to thermal fatigue. On the question of corrosion resistance it is recalled that in steam and gas turbines the basic consideration is the direct combination of the metals with oxidising gases, and the effect of adding a percentage of chromium to alloy steels upon the service temperature and resistance to oxidation is noted.

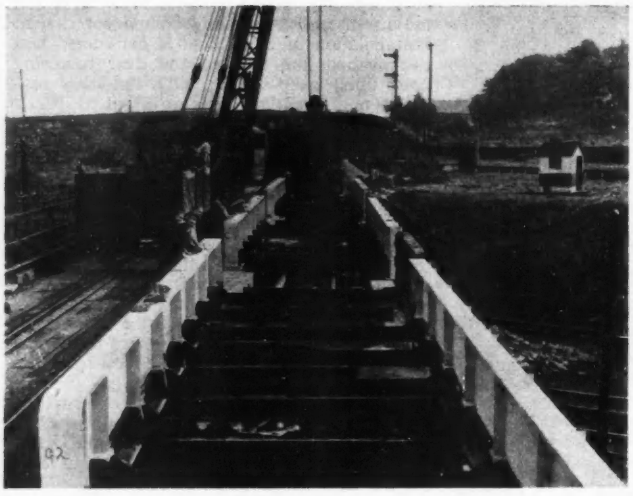
The next section of the paper deals with the various treatments adopted in the manufacture of high-temperature alloys, such as ferritic steels and austenitic alloys and then proceeds to discuss the composition and properties of certain specific high-temperature alloys. These include carbon-molybdenum and chromium-molybdenum steels, ferritic steel containing molybdenum and vanadium, higher chromium and non-hardenable ferritic steels, austenitic alloys and steels, and nickel and cobalt base alloys. The next subject mentioned is welding and, after generally discussing the metals to be welded, the effect of service condition on welds is considered, including graphitisation and intergranular cracking. The high-temperature properties of welds come under discussion and with regard to certain alloys it is mentioned that there will be a narrow band close to the weld which is weaker than the parent metal. It is stated that no abnormal difficulties are anticipated in welding austenitic steels to each other or a metal-base alloy to another. However, additional difficulties occur in welding ferritic steels to austenitic steels or nickel-base alloys and also austenitic steels to nickel-base alloys. The paper includes tables giving the composition of various steels, curves of creep strain drawn to different bases, relaxation curves and a graphical comparison between carbon-molybdenum and chromium-molybdenum steel on a basis of stress to rupture and elongation to rupture.

Reconstruction of a Railway Bridge

A COMBINATION of welded steelwork and prestressed concrete has been used in the reconstruction of a railway bridge at Carlisle. The bridge is of three spans of about 40ft each and carries a double line branch from the main Lancaster and Carlisle line to Crown Street goods depot, over the Settle and Newcastle to Carlisle lines. A very small construction depth was available for the new structure, due to the steep gradient into the goods yard and the very low headway under the bridge. Traffic both over and under the bridge is heavy, and a form of construction had to be devised which could be erected with the minimum interference with the running of trains.

The design eventually adopted comprised a "through" bridge with two outer girders and one centre girder in each span, with prestressed concrete floor slabs spanning between them, on which steel plates were placed, with the running rails attached to them, thus reducing construction depth to a minimum. The girders are all welded and have intermediate web stiffeners at 6ft centres with shear-plate connections to carry the corners of the deck slabs. Thus the slabs do not bear on the bottom flanges of the girders and floor loading is transmitted to the web. The three girders in each span are tied across at 6ft intervals by steel "tee" sections; they rest on welded steel pedestal bearings, giving easy access for inspection and painting.

To facilitate erection and to cut down occupation time the prestressed concrete floor slabs were precast in 6ft. They are 12in thick and weigh about 5 tons each and they were prestressed by the Freyssinet method using twelve wire cables. Direct rail to concrete support was continued over the piers and because of the necessity of avoiding interference with traffic, the concrete here also was precast in slabs similar to the main spans.



Main Girders and Transverse Ties

The low headway precluded the use of smoke-plates and, therefore, to protect the steelwork from smoke and blast the bottom flanges of the main girders were aluminium sprayed before erection to a thickness of 0·006in and the remainder of the exposed steelwork was also sprayed with aluminium to a thickness of 0·003in. The underside of the concrete slabs in the main spans was sprayed with a bitumen compound, while the top surfaces of all slabs were treated with a hardening solution.

The site work was carried out by first removing the whole of the existing superstructure, one span at a time, and erecting temporary waybeams to carry one line of traffic into the goods yard as each span was demolished, thus allowing half of the existing abutments and piers to be prepared for the new superstructure. At subsequent week-ends the new steelwork and deck slabs for the whole length of this side of the bridge were placed and a temporary sleepered track laid over the new decking. The temporary waybeams were then removed and the remaining portions of abutments and piers were prepared as before to accommodate the second half of the superstructure and so complete the new bridge.

The design was prepared and detailed by the civil engineer of the London Midland Region and the welded girders and concrete slabs were fabricated in the Region's shops at Newton Heath, Manchester, while the site work and erection was carried out under the supervision of the Region's district engineer, Lancaster.

Extensions to an Industrial Truck Factory

EXTENSIONS recently opened at the Basingstoke works of Lansing Bagnall, Ltd., have doubled the firm's manufacturing capacity for tractors, industrial and fork-lift trucks. The new extension is in the form of a complete bay some 500ft long by 50ft wide, 14ft high at the eaves and 28ft high at the ridge. It is a portal frame structure of reinforced concrete giving a clear, unobstructed floor space. Two-storey offices are situated at each end of the building and arranged in an overhead structure suspended from the roof members at one end of the building are offices for the design development department and the service and spares departments.

The new extension is being used mainly for the assembly of vehicles, and the removal of this work from the original shops has made it possible to rearrange them and provide additional accommodation for the component machining departments. A large number of new machines have been introduced in the machining sections to meet increased production demands.

In the new shop the manufacture of units for the main members such as frames, chassis, &c., begins in a press and sheet metal working section at one end of the bay. The parts are assembled in a welding department well equipped with jigs and manipulators. In subsequent production stages the main members and pre-assembled units are fitted together, tested and painted. A machine section and tool-room laid down adjoining the assembly lines are equipped for the production of special parts and modifications on vehicles to suit individual customer requirements, and the servicing of tooling and equipment used in the shops. This machining section also supplies parts for a development section and a servicing and vehicle overhauling department.

All parts are delivered to a stores area at the top of the shop on pallets and, as required, the pallets are transferred to the assembly section by means of fork-lift trucks. Other than in the machine sections the floor layout is quite flexible and the use of pallets for parts renders unnecessary fixed storage bins. It should be mentioned here that after assembly each vehicle undergoes detailed inspection and testing, and it is then placed in general works service for at least two days before it is finish painted ready for despatch. During its works service a vehicle is put through all its operations.

Three new industrial vehicles recently introduced by the firm were shown at the official opening of the new extensions last week. These vehicles included an electrically operated fork-truck fitted with a fixed mast and tilting carriage; a pedestrian controlled battery-electric pallet truck, and an industrial tractor fitted with a 16 b.h.p. diesel engine giving a top speed of 20 m.p.h. with a sustained drawbar pull of 1100 lb.

Corrosion on Steel-Cored-Aluminium Overhead-Line Conductors*

By J. S. FORREST, M.A., D.Sc., M.I.E.E.,† and J. M. WARD, B.Sc.†

WHEN the Grid system was designed it was decided to use steel-cored aluminium (s.c.a.) for the overhead transmission lines, and in the years 1928–33 some 20,000 miles of s.c.a. conductors were erected. There was no previous large-scale experience with such conductors in Britain, and it was appreciated that difficulties might arise from corrosion, particularly in industrial and coastal atmospheres. Accordingly, arrangements were made early in 1933 to initiate a programme of tests on samples of conductor taken from selected localities in industrial and coastal districts. The object of this work was to study the rate of deterioration of the mechanical and electrical properties of the conductors operating in various atmospheric conditions. Such information would enable the service life of the conductors to be estimated.

The first series of tests was made in 1934 and thereafter biennially until the outbreak of war in 1939. However, essential tests were made during the war whenever it was necessary to obtain information in order to forestall conductor failures in service. In the post-war period the scope of the work was increased again, and a survey was made of a large number of samples taken from lines in various parts of the country. In addition to selecting samples from industrial and coastal districts which might be expected, or were known, to exhibit fairly severe corrosion, an attempt was made to include samples which were representative of the condition of the conductors in general. The results obtained illustrate the various types of corrosion to which s.c.a. conductors are prone and provide data on the service life of the conductors under British conditions. In addition, methods of preventing or reducing corrosion have been investigated, both in the laboratory and in the field.

The paper summarises this work and gives the conclusions reached as a result of experience which now extends over a period of twenty years.

[Here the authors described the methods of measuring corrosion and the test programme.]

TYPES OF CORROSION

Although the rates of corrosion of line conductors in industrial and coastal areas do not differ markedly in industrial areas the attack is most severe on the outer strands, whereas in coastal areas the attack on the outer and inner strands is, on the average, of equal severity. An insufficient number of samples was available for a similar comparison to be made for earth wires, but it has been evident from examination of the samples that the two types of attack also occur with these conductors. The characteristics and difference in type of attack can be best illustrated by considering the worst cases from the industrial and coastal areas.

Industrial.—The first examples of serious corrosion in industrial districts came from Liverpool and Rotherham.

Samples of line conductor which had been nine years in service were examined from the ends and centre of three spans (1–2, 15–16, 27–28) of the Clarence Dock-St. Helens line, which runs for about 4 miles over the Leeds and Liverpool canal into Liverpool. The outside of the samples was heavily coated with a black scale having an outer friable layer which, when removed, left a thinner more tenacious scale flecked with greyish patches. The outer aluminium strands were corroded to such an extent that they appeared flat. There was a loose greyish-white corrosion product between the layers of aluminium strands and between the inner layer of aluminium and the steel core. Deep elongated pits could be seen under the corrosion product, distributed fairly uniformly over the strands. The galvanising had been removed in places from the core, but the steel was not heavily attacked. Tests showed that the outer aluminium strands had tensile strengths

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† British Electricity Authority Research Laboratories.

varying between 47 and 73 per cent of the original values, and showed an increase in resistance varying between 12 and 31 per cent of the original value. The inner aluminium strands had strengths varying between 49 and 89 per cent of that specified, and showed increases in resistance from 3·1 to 5·5 per cent. The strengths of the steel strands of the core varied between 99 and 109 per cent of the specified value.

Six samples of line conductor from Rotherham examined after nine years in service had also been severely corroded and showed the same type of attack. The outer aluminium strands showed a 25–30 per cent reduction in cross-sectional area, and some were reduced in strength by 75 per cent. The increase in resistance was as high as 58 per cent on one sample. The inner aluminium strands had strengths between 60 and 80 per cent of the specified ultimate, and showed an increase in resistance to a swelling large enough to cause breaking of the aluminium strands.

The time taken to reach a serious state of corrosion varies, and in some districts conductors are in good condition after fifteen years. The most severe attack has taken place at the Hayle end of the Hayle-Fraddon line, where it runs within a quarter of a mile of the north Cornish coast. Three years after this line had been erected the earth wire on several spans had to be replaced, because bulging had occurred in very many places to such an extent that many aluminium strands were completely severed. The bitumen protection on the steel core was crumbling, and beneath it the galvanising was removed in large patches. The steel core was otherwise not seriously affected, however, and its strength was 105 per cent of that specified.

Three years later the replacement earth wire, the core of which had been protected with a

Changes in the Physical Properties of Conductor Strands Due to Corrosion

Location	Age	*	Loss in ultimate tensile strength	Weight loss	Loss in diameter	Zinc on steel core†	Remarks
	Years		Per cent	Per cent	Per cent	Oz/ft²	
Portsmouth-Reading, tower L.178 (37/·11in)	16	O	4	8	4	0·97	
		I	4	2	0		
Lancaster-Natland, span F1–126 (37/·11in)	17	O	24	11	5	0·43	Two severe bulges with broken strands and 13 small bulges in 17ft length of sample
		I	—	2	0		
Agecroft-Chadderton, span J55–56 (37/·11in)	18	O	53	24	14	0·66	Outer aluminium strands broken in several places
		I	—	18	0		
Cardiff - Lydney, span 128 – 9 (19/·11in)	5		0	2	1	0·71	
Cardiff-Lydney, span 115A–128 (19/·11in)	15		0	6	2	1·01	
Percival Lane substation (19/·11in)	16		65	20	11	0·62	Aluminium strands broken in several places
Dalmarnock-Port Dundas No. 1, route A,span 18–18A (37/·11in)	20	O	46	25	10	0·72	Outer aluminium strands broken in several places
		I	20	14	0		
Dalmarnock-Port Dundas No. 2, route A, span 18–18A(37/·11in)	20	O	55	26	15	0·71	Outer aluminium strands broken in several places
		I	22	6	0		
Percival Lane-Crewe, span A11-A12 (37/·11in)	16	O	13	9	5	0·80	
		I	0	2	1		
St. Helens - Warrington, span C128-130 (37/·11in)	16	O	13	9	5	0·87	
		I	2	2	0		

* O=Outer aluminium strands. I=Inner aluminium strands.
† B.S. 443 : 1939 specifies 0·80 oz/ft² for new galvanized strands.

averaging about 3 per cent. The strengths of strands of the steel cores were, on average, 110 per cent of the specified value.

Severe corrosion has also occurred in other cases, e.g. on the conductors on the Agecroft-Chadderton, the Lancaster-Natland and the Dalmarnock-Port Dundas lines, and on the earth wires at Percival Lane substation. Samples from these lines were examined ; the losses in weight and cross-section of the aluminium strands and the amount of galvanising remaining on the core were measured. The results, with those from conductors less heavily attacked, are given in the table. Where possible, a figure is also given for the percentage loss in tensile strength of the aluminium strands. The figures illustrate the typical heavy attack of the outer strands resulting in loss of cross-section and strength, and the different type of attack on the inner strands which have been pitted and therefore weakened, but no uniform loss in cross-section has occurred. The figures given above for the increase in resistance also show the difference in type of attack. The resistance of the outer layers is considerably increased, but the isolated pits on the inner strands have caused little increase in resistance.

The foregoing cases are among the worst examined, but are typical of the corrosion taking place in heavily industrialised districts. Many conductors from districts less heavily polluted by industrial emissions have not been corroded so severely, but the characteristics of the attack are the same. As the degree of industrialisation lessens, so does the severity of corrosion, and in rural districts the attack on the inner aluminium strands is almost negligible, but there is usually some uniform slight pitting of the outer aluminium strands.

Coastal.—Broadly speaking, serious corrosion in coastal districts takes the form of bulges or swellings caused by corrosion products between the steel core and the aluminium strands. These bulges occur at irregular, but often frequent, intervals along the conductor, the amount of corrosion product varying from a small layer bitumen thought to have better weathering properties than the type originally used, was found to be corroded almost as badly as before. The line conductor was also found to be attacked in the same way, and in one section bulges of corrosion product occurred at intervals corresponding approximately to the lay of the steel strands. The strength of the steel strands of the core was again above that specified.

Conductors in other coastal districts have developed bulges and shown similar corrosion characteristics, but after longer periods. For instance, the conductors from the Newhaven-Lewes line reached a serious state of corrosion after about fifteen years, those from the Dorchester-Exeter line after twenty years.

Although corrosion is worst at the bulges between the inner aluminium strands and the steel core, deep pitting of a type similar to that found in heavily polluted industrial districts often takes place between the aluminium strands of the two layers in line conductors. The attack on the outer surfaces of the conductors is very slight, however.

[The authors went on to discuss the mechanism of conductor corrosion and the effectiveness of remedial measures.]

Conclusions

The mean rate of deterioration of s.c.a. conductors in Great Britain, expressed in terms of the loss of mechanical strength of the complete conductor, is 0·4–0·5 per cent per year, which corresponds to a mean service life of twenty-five to thirty years.

The rate of deterioration varies greatly in different localities. Conductors in heavily industrialised areas may have a life of ten years or less, but in rural districts many conductors are in excellent condition after twenty years' operation and may be expected to have a life of at least fifty years.

Earth wires generally appear to deteriorate more slowly than line conductors, and the average expected service life is thirty-five to fifty years. A life of only a few years is likely, however, if unprotected earth wires are exposed to wind and sea spray ; under these conditions an earth wire has had to be replaced after three years.

Broadly speaking, two types of corrosion have emerged, namely, industrial and coastal. Industrial corrosion consists of a fairly uniform attack on the exposed surfaces of the aluminium, often accompanied by deep pitting of the internal surfaces of the aluminium strands. Coastal corrosion is essentially electrolytic corrosion between the aluminium and the steel core, again accompanied by attack between the aluminium layers. Analysis of results from ninety-five line conductors in inland districts has shown that the outer strands corrode more rapidly than the inner strands. Analysis of thirty-four results from conductors in coastal districts showed that the rates of attack on outer and inner aluminium strands were about the same. In severe cases, however, the inner strands in contact with the steel core were corroded much more heavily than the outer strands, causing the characteristic bulging of the conductor. The steel core of all the conductors examined has been found to be in very good condition, even when the aluminium has been severely corroded. This confirms the electro-chemical nature of the attack.

Steel-cored aluminium conductors appear to corrode appreciably faster than larger surfaces of aluminium, such as roofs, the stranded nature of the conductor and the effects associated with the electrical load being held mainly responsible for the difference. The latter effects probably explain the slower rate of deterioration of earth wires compared with the live conductors.

Treatment of conductors with suitable greases has been found to be effective in preventing corrosion under the worst conditions likely to be encountered. The increased costs incurred during manufacture and erection are small in comparison with the saving in replacement costs, especially on conductors exposed to severe conditions.

For maximum protection in industrial districts, complete impregnation, including a thin layer of grease on the outside of the conductor, is necessary. In coastal districts the same treatment will give maximum protection, but to keep down the cost of erection, the layer on the outside may be dispensed with, provided that sufficient grease is applied to the penultimate layer to squeeze through the interstices between the outer strands and seal the conductor. Bitumen is not an effective corrosion preventive, since in time it cracks, hardens or disintegrates.

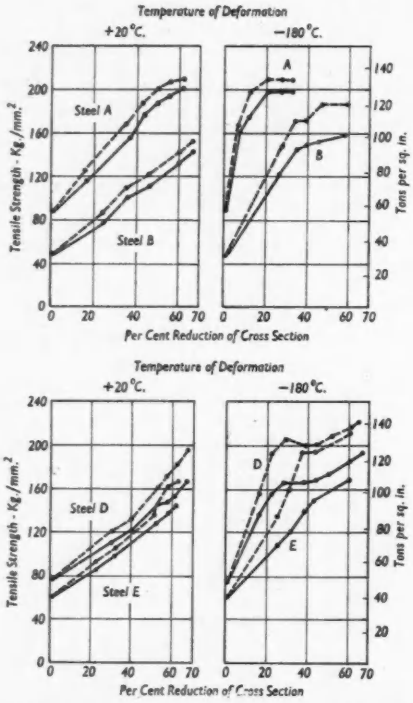
Non-Inflammable Material

We were recently invited to a demonstration of the fire-resisting properties of a material known as " Secondite," which was arranged by the Secondite Company, Ltd., 25, Millbank, London, S.W.1. " Secondite " is made from rice hulls, treated by a biological process, no details of which were given by the company, but which was stated to leave the hulls in an inert condition, as an inorganic substance of high silica content. It is made in three grades, two of which can be bonded with cement or magnesite to make a building board or similar material. The high fire-resistant and heat-insulating properties of the material are due, Secondite, Ltd., states, to the retention of one of the properties of the growing rice hulls, viz., that they are impermeable to oxygen, but permeable to carbon dioxide ; this property is exhibited by " Secondite," it is claimed by the company, above a certain temperature. It was shown that a comparatively thin sheet of it was able to withstand an oxy-acetylene flame for a minute or two, without appreciable rise in temperature on the other side of it. At ordinary temperatures the material acts as a filter, and one use claimed for it is to replace the carburettor and petrol pump of a car engine. The company states that a car has been run with a " Secondite " filter 5 cm thick in the petrol tank connected to the engine manifold, through a pipe incorporating a control valve, and with an air intake into the tank, so that petrol vapour is drawn into the engine as it takes air through the filter. A higher power output and fuel economy is claimed for this arrangement.

Metallurgical Topics

Effect of Deformation at Low Temperatures on the Properties of Austenitic Stainless Steels

A PRONOUNCED increase in yield stress, tensile strength and hardness, with a fall in elongation, is characteristic of cold-worked austenitic chromium-nickel steels, especially of those which approach or fall within the $\alpha+\gamma$ region in the equilibrium diagram. There is much evidence to show that deformation at sub-zero temperatures will induce higher yield, tensile strength and hardness than a similar amount of deformation at room temperature. The effect upon the steel of deformation at low temperature depends on its



The full lines show the properties of the cold-worked steels before, and the broken lines after, annealing.

Composition, per cent	Steel A	Steel B	Steel D	Steel E
Carbon	0·14	0·06	0·07	0·06
Chromium ...	17·98	17·26	18·33	18·30
Nickel	7·63	11·27	8·34	11·82
Molybdenum ...	0·10	0·07	2·21	2·19

Figs. 1 and 2—Influence of Temperature and Amount of Deformation on the Tensile Strength of Steels Without and With Subsequent Annealing for Twenty-four Hours at 400 Deg. Cent. (Bungardt, Oppenheim and Scherer).

composition, and is influenced by the proportion of austenite and ferrite-forming elements present.

Experiments made to investigate the practical application of sub-zero deformation as a method of improving the properties of austenitic stainless steels, have been described by K. Bungardt, R. Oppenheim and R. Scherer,* who determined the effect of deformation at −70 deg. and −180 deg. Cent., and of subsequent annealing (especially for twenty-four hours at 400 deg. Cent.) on the tensile properties and hardness, the structure, the magnetic properties and corrosion resistance of a series of austenitic chromium-nickel, chromium-nickel-molybdenum, and chromium-manganese steels.

The austenite-ferrite transformation in stainless steels containing unstable austenite is favoured by deformation at low temperatures. This well-known effect was confirmed by magnetic tests and X-ray analysis. A higher tensile strength was reached by austenitic stainless steels after deformation at low temperatures than after a similar amount of deformation at room temperature; and the increase, due to the lower temperature of deformation, was more pronounced in steels with unstable austenite than in steels of higher nickel content in which the austenite was more stable. Examples are shown in Figs. 1 and 2. To give the same tensile strength, less deformation is necessary at low temperatures than at room temperature. For equal tensile strength the elongation of the steel deformed at low temperature was greater than that of the steel deformed at room temperature. The reduction of area, however, varied only with the tensile strength and was practically independent of the temperature of deformation. The dependence of the increase in tensile strength, due to deformation at low temperatures, on the extent of the transformation of austenite to ferrite was shown by magnetic tests on steel D after deformation at +20 deg. and −180 deg. Cent. The tensile strength, and the magnetic saturation ($4\pi J_\infty$), varying with the amount of ferrite present, both increase more rapidly with deformation at −180 deg. Cent. than with deformation at room

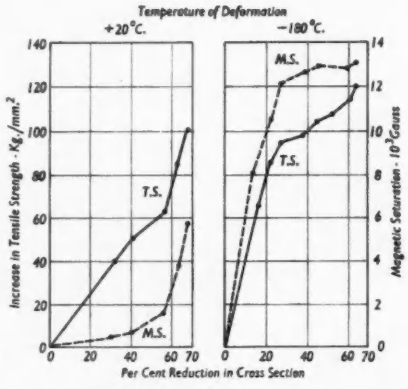


Fig. 3—Influence of Temperature and Amount of Deformation on the Increase in Tensile Strength (T.S.) and on the Magnetic Saturation (M.S.) of Steel D (Bungardt, Oppenheim and Scherer).

temperature, as shown in Fig. 3. The composition of the steel is given under Figs. 1 and 2.

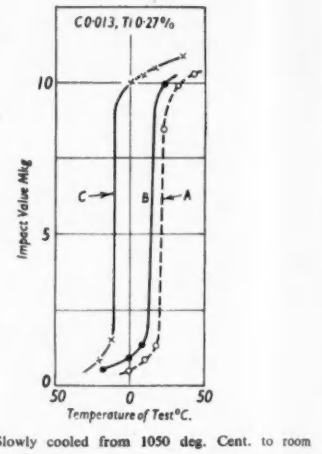
By annealing the low-temperature deformed steel at about 400 deg. Cent a considerable further increase in the yield point, tensile strength and hardness could be obtained. The magnitude of the effect was dependent on the amount of ferrite formed as a result of the previous deformation. Whether alloy elements, such as molybdenum, silicon, niobium, tantalum and titanium, influence the effect of annealing at 400 deg. Cent. directly, or indirectly by favouring the formation of ferrite, remains an open question. On annealing for twenty-four hours at 400 deg. Cent. the reverse transformation, $\alpha\rightarrow\gamma$ or ferrite→austenite sets in, and the change is completed in a shorter time at 650 deg. Cent. Below 650 deg. Cent. the adjustment of equilibrium is very slow. The austenite→ferrite transformation, induced by cold working, also favours the formation of the sigma phase which was clearly detected in the chromium-nickel-molybdenum steel D, cold worked 60 per cent at −180 deg. Cent. and annealed for 2200 hours at 550 deg. Cent.

The effect of deformation at low temperatures on corrosion resistance was not examined in great detail, but it was concluded that the concentration-temperature range of corrosive media which produce passivity was unaltered by the $\gamma\rightarrow\alpha$ transformation, but that in the active condition an increase in corrosive attack might be expected.

Titanium-Stabilised Mild Steel

A STUDY has been made by A. Josefsson and B. Nelson[1] of the quench-ageing and strain-ageing of some low-carbon steels to which titanium has been added. This is a subject on which much previous work has been done, and on which fairly definite conclusions have been reached as a result of hardness, tensile and notched-bar impact tests carried out at room temperature. The aspect of the subject on which Josefsson and Nelson provide additional information is the transition temperature of these steels from tough to brittle fracture in Charpy tests, and character of the impact figure/temperature curves.

The steels investigated contained carbon 0·006 to 0·025, titanium 0·11 to 1·00, and aluminium (increasing with titanium content) 0·008 to 0·130 per cent. There was also present 0·007 to 0·021 per cent of nitrogen. In most of the steels the titanium was amply sufficient to



Curve *A*.—Slowly cooled from 1050 deg. Cent. to room temperature.
Curve *B*.—As above, then reheated at 700 deg. Cent. for one hour and quenched: stretched 10 per cent and heated at 200 deg. Cent. for six hours.
Curve *C*.—The forged steel heated to 700 deg. Cent. and quenched.

Fig. 1—Impact Value as a Function of Temperature in Steel Containing Carbon 0·013, Titanium 0·27 Per Cent.

combine with the carbon and nitrogen present to form titanium carbide and nitride. The steels were tested in the annealed, strain-aged and quench-aged conditions, and also after heat-treatments designed to give maximum differences in grain size. The transition temperatures were almost invariably sharply defined, a range of only about 10 deg. Cent. separating completely tough and completely brittle fracture. This form of impact figure/temperature curve is characteristic of high purity ferrite. The transition temperatures varied from −20 deg. to

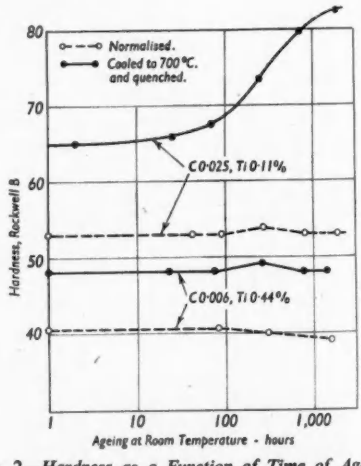


Fig. 2—Hardness as a Function of Time of Ageing After Normalising and After Quenching from 700 Deg. Cent.

+20 deg. Cent. for the material in its original condition, and from −15 deg. to +50 deg. Cent. after straining and ageing. The lower (sub-zero) temperatures were characteristic of the fine-grained steel obtained without any austenitising treatment after forging, and the higher transition temperatures were shown by coarse grained

* *Archiv für das Eisenhüttenwesen*, September/October, 1953, page 423.

material. Variations in the rate of cooling in the temperature range below 700 deg. Cent. produced no significant differences in the transition temperatures, such as may be obtained in steels of the same basic composition but without titanium. Fig. 1, which refers to a steel having ample titanium to combine with the carbon and nitrogen, illustrates the lower transition temperature of the fine-grained material (curve *C*), but also shows that in the coarser-grained steel with higher transition temperature (curve *A*), quench- and strain-age-embrittlement are absent, the transition temperature (curve *B*) being actually a little lower.

Judged by hardness tests, none of the steels exhibited quench-ageing effects after being normalised or slowly cooled from above the critical range, and only those low in titanium showed any sign of ageing after a treatment consisting of heating at 950 deg. Cent., cooling to 700 deg., and quenching from that temperature. Thus, steel containing carbon 0·025, nitrogen 0·018 and titanium 0·11 per cent showed definite quench-ageing characteristics after this treatment, but one containing carbon 0·006, nitrogen 0·021 and titanium 0·44 per cent did not (Fig. 2). Here the titanium was more than sufficient to convert the carbon and nitrogen into an insoluble form. Whereas the solubility of carbon in ferrite is usually taken as being 0·035 per cent at 700 deg. Cent., falling to 0·007 per cent at 200 deg. and below, it is claimed by Josefsson and Nelson that, in the presence of titanium carbide and nitride, internal friction measurements indicate that the solubility of carbon and nitrogen in the ferrite must be very much smaller, probably below 0·0005 per cent.

It was shown by C. A. Edwards, D. L. Phillips and H. N. Jones[2] that only a small excess of titanium over that required to form titanium carbide with the carbon present was necessary to prevent strain age hardening; and J. A. Jones[3] gave the same ratio (4 : 1) as sufficient to eliminate both the hardening and the embrittling effects of ageing after quenching from 650 deg. Cent. Later, L. Northcott and D. McLean,[4] in an extensive study of the properties of titanium steels, confirmed the effect of titanium, but suggested six times the carbon content as usually necessary in practice in order to render the nitrogen inert as well as the carbon. Now, Josefsson and Nelson have given further confirmation of the effect in the approximate constancy of the transition temperature when titanium is present in more than sufficient quantity to combine with all the carbon and nitrogen.

REFERENCES

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[2] *Journal of the Iron and Steel Institute*, 1940, Vol. 142, page 199.
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[4] *Journal of the Iron and Steel Institute*, December, 1947, Vol. 157, page 492.

Centrifugal Separation

INDUSTRIAL applications of centrifugal force to the problem of separating solid and liquid phases have in the past been limited largely to aqueous systems at or near room temperature. In a report issued by the United States Bureau of Mines, A. K. Schellinger and M. J. Spendlove* foreshadow its application to the separation of solid and liquid phases in metallic systems.

In the field of industrial metallurgy, liquid and solid separations are often made at a high temperature where the liquid is a molten solution of metals, or may be of a non-metallic character, e.g. silicates. Gravitational force is the usual means of effecting the separation when the liquid and solid phases differ markedly in density. Thus, a crust of solid phase may be skimmed from the surface of a kettle of molten metal after a given separation time, or the solid may settle as a sludge to the bottom of the kettle and be separated by decantation. Separations of this nature, though the usual practice in industrial metallurgy, suffer from the diadvantages of slowness, incompleteness and the use of hand labour.

In recent years, some progress has been made in both laboratory and plant separations of liquid and solid phases in metallic melts by filtering and by centrifuging. Filtration technique has been used for plant-scale separation of the iron-tin intermetallic compound from liquid tin, an operation which lowers the iron content of the tin to 0·01 per cent. Filtration has also been used on an experimental scale to refine lead, zinc and aluminium alloys. It is reported that molten metal centrifuges are in use in France for pilot plant refining of crude aluminium-silicon alloys, and the report gives reference to numerous experimental applications of the process.

The exploratory work now described was aimed at comparing the centrifugal separation of phases in simple binary alloys with the theoretical separation as indicated by the equilibrium diagram, and is concerned primarily with alloys of lead having comparatively low liquidus temperatures. The apparatus consisted of a 3in by 3in plain carbon steel pot, supported on a vertical axle and enclosed in a small gas furnace. The apparatus, in principle, is shown in Fig. 1. The pot was enclosed in an insulated

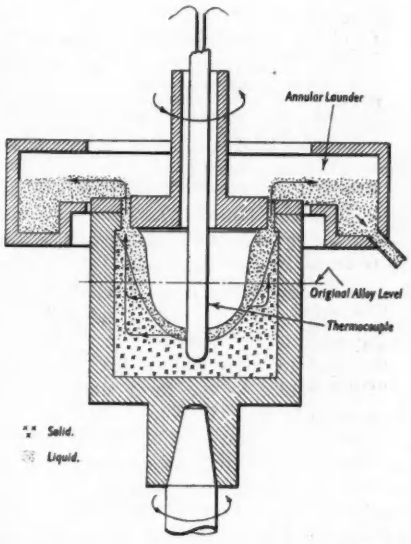

Fig. 1—Vertical Section Through Spinning Pot and Launder

container and heated by horizontal gas burners (with automatic gas-regulating valves), the flames of which were directed into an annular combustion chamber from which the hot gases were led up into the furnace chamber surrounding the pot. Temperatures up to 800 deg. Cent. could be maintained to within ±5 deg. by this arrangement, which is illustrated in the report. In these experiments, an alloy was held in the spun pot at a temperature between its liquidus and solidus. Solid crystals were thrown outwards against the wall with such force that frictional resistance to any motion along the axis of rotation was increased. Meanwhile, the liquid metal filtered through the interstices of the solid crystalline aggregate which was resting heavily against the wall of the spun pot, ran up the wall and over the top edge, as indicated in Fig. 1.

Experiments were carried out with binary alloys of lead with tin, bismuth and antimony, operating with compositions and temperatures which fell between the liquidus and solidus lines, i.e. within two-phase regions of the equilibrium diagram. In general, comparison of the actual yield of liquid with the theoretical amount indicated by the equilibrium diagram showed that the efficiency of centrifugal separation was usually over 90 per cent. In an antimony-lead type metal containing 20 per cent antimony, recovery of the 95 per cent antimony solid solution was very near to theoretical. Bismuth shows a smaller solubility in lead than antimony does, and is not so readily wetted by the liquid phase. Accordingly, purer crystals and drier cakes were obtained from the bismuth alloys. The 80 : 20 bismuth-lead alloy at 145 deg. Cent. yielded large, well-defined, sharp-cornered crystals of bismuth.

Successful separations of intermetallic compounds from alloy melts were obtained with binary mixtures of 95 per cent lead, bismuth or tin and magnesium and from 95 : 5 tin-iron alloys. Liquid recovery in these cases exceeded 90 per cent, and analysis of the intermediate compounds conformed closely to the phase diagram compositions. The compounds were in the form of dry masses of needlelike crystals.

In the opinion of the authors centrifugal separation of the tin-iron intermetallic compound appears feasible and promises more rapid and complete separation than the industrial filtration procedure now used. It may be noted, in passing, that the temperature used by the authors in separating tin-iron was 400 deg. Cent. and that the solid contained 23 per cent of iron rather than the theoretical 19 per cent corresponding to $FeSn_2$, the compound said to be stable at this temperature. This was attributed to admixture of FeSn. As FeSn, with 32 per cent of iron, is not the stable phase at temperatures below about 500 deg. Cent., this raises the question of attack on the container. Corrosion of the pot is an objection sometimes raised against the use of centrifuges at high temperatures, and heat-resisting alloys may have to be used. The French use 30 per cent chromium-iron which is said to give good service with aluminium alloys. The authors appear to be satisfied with the use of a mild steel pot, at least up to 400 deg. and possibly 500 deg. Cent., but corrosion of the pot by molten metal is a matter which would require careful watching and investigation.

Summing up, however, the authors appear to be justified in their conclusion that high-temperature centrifugal technique for scrap alloy metallurgy, explored briefly in their investigation, merits increased experimental attention, because more rapid and complete metallic phase separations are thus possible than are offered by present commercial technique, and because corrosion problems with low melting point scrap alloys do not seem to be serious, even with a low-carbon steel spinning pot.

Hardening of Aluminium Alloys

IN a monograph on "The Modifications of Structure of the Metallic Crystal and their Influence on the Kinetics of the Structural Hardening of Solid Solutions of Aluminium," Dr.-Ing. A. Berghezan* describes how the crystals of the solid solution can undergo important modifications of structure, both intergranular and within the grains, with marked effect on the rate of age-hardening of the alloy. These changes are brought about by different thermal and mechanical treatments applied before, during or after quenching. All the previous history, thermal and mechanical, plays an essential part in determining the rate of decomposition of the solid solution, which is influenced by three principal factors: severity of quenching, mosaic structure or polygonisation, and mechanical deformation applied immediately after quenching. Structural hardening of the alloys depends not only on composition, but to a large degree also on the structural condition of the metallic crystal at the time of age-hardening. This structural condition may be profoundly affected by any treatment which can produce or redistribute internal defects within the metallic crystals. From the very beginning of the ageing process these defects of structure, in their turn, affect the distribution of the dissolved atoms. Dr. Berghezan takes account of this important factor, and special attention is given to the study, by micrographic technique and X-ray analysis, of structure before hardening and its relation to rates of diffusion and the kinetics of the age-hardening process.

The report, to which Professor Chaudron contributes a preface, is illustrated by a number of excellent micrographs including one in colour, in which polygonisation is revealed by interference tints on the surface of an anodically oxidised aluminium-zinc alloy. The observed structural conditions are correlated with the mechanical properties of the final product, thus giving the report a definite practical value in addition to its scientific interest.

* "Centrifugal Separation of Liquid and Solid Phases from Some Binary Alloys," U.S. Bureau of Mines Report of Investigations, 5007. November, 1953.

* *Publications Scientifiques et Techniques du Ministère de l'Air*, No. 283: *Magasin C.T.O.*, 2, Avenue de la Porte-d'Issy, Paris (15e). Price 1200f.

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OPERATING EXPERIENCE WITH GAS TURBINES

In a paper read at Chicago in 1952, Mr. Claude Seippel indicated three typical epochs in the history of gas turbine engineering. The first, around 1900, he described as the "epoch of great inventors, of men acting by intuition more than by reasoning and computation. They created an almost perfect diesel engine and a fair steam turbine, but no gas turbine worthy of the name." The second epoch witnessed the onset of "more precise theoretical thinking to assist intuition." It saw the growth of steam turbines to 100,000kW and produced the first working gas turbine. The third epoch—in which we now find ourselves—is "the epoch of wind tunnels, of metallurgical laboratories, of research on combustion, of physicists and chemists assisting the engineer." Mr. Seippel concluded by remarking that "the gas turbine is a very pretentious machine which, unlike the combustion engine and the steam turbine, had to await the advent of the third epoch before it could be made a success."

Some tangible evidence of the emergence of the gas turbine as a commercial machine is given in the paper read on January 21st—before the Diesel Engine Users Association—by Mr. E. A. Kerez, of Brown, Boveri and Co., Ltd. This interesting paper contains an account of "Operating Experience with Gas Turbines with Particular Reference to Beznau Power Station," and thus relates to the largest gas turbine plant yet built. With a total installed capacity of 40,000kW, the Beznau station accounts for as much as 28 per cent of the collective capacity of the thermal power stations existing to-day in Switzerland. At the time the gas turbine equipment for Beznau was ordered operating experience on gas turbines working for extended periods with a temperature of 600 deg. Cent. was not available. The first set (13,000kW) was ordered from Brown, Boveri and Co. Ltd. in June, 1946. It was ready for running in December, 1947. The second set (27,000kW) followed in January, 1949. Mr. Kerez now gives a chronological account of the operational difficulties experienced and the means adopted for overcoming them. Among other troubles, there was an early failure (by breakage) of three blades in the third stage on the high-pressure gas turbine rotor of the 13,000kW set. The solutions found for this and certain other troubles are generously set forth in the paper, which includes, with other significant illustrations, a photograph of the high-pressure gas turbine rotor of the 13,000kW set after 7900 hours' running time. Particulars are also given of experience—notably maintenance experience—with the gas turbine plants at Dudelange (Luxemburg) and Pertigalete (Venezuela) In the case of the 5400kW gas turbine at Dudelange—which burns blast-furnace gas—not a single spare part has yet been used though the set is now in its third year of industrial service. Of this equipment it is related that it started up in April, 1951, and that the turbine ran for over 4000 hours that same year "and on November 30, 1953, had a running record of 14,783 hours, during which time it delivered 79,288,500kWh." It has thus been running throughout the entire period with an average load of 5363kW. We read that the blast-furnace gas burned by this machine contains an average of 3mg to 4mg of dust per cubic metre and has a calorific value of about 950 cal. per cubic metre, equal to, say, 106 B.Th.U. per cubic foot. Reading this paper by Mr. Kerez along with the Gas Turbine Progress Report submitted to the Chicago meeting (1952) of the American Society of Mechanical Engineers, the paper "The Problem of Fuel Oil Ash Deposition in Open-Cycle Gas Turbines," recently presented to the Institution of Mechanical Engineers by Messrs. A. T. Bowden, P. Draper and H. Rowling, and the latter part of the Thomas Lowe Gray lecture by Dr. T. W. F. Brown, printed in this issue, we realise how rapid, during the last ten years, has been the development of the gas turbine as an industrial machine. While warmly applauding the Swiss achievements recorded by Mr. Kerez, we are gratified to note the important part played by manufacturers and research workers in Great Britain, the United States and other countries.

There is an old Italian proverb which tells us that "He who goes slowly goes wisely and he who goes wisely goes well." Certainly the gas turbine has gone slowly if we look back over the hundred and sixty-three years which have elapsed since John Barber, a Nottinghamshire coal master, received the grant of a patent describing the essential features of this kind of prime mover. In the interim much work, both imaginative and practical, has been recorded, and we remember from the past the names of Dumbell, Fernihough, de Telescheff, Parsons, Curtis, Amsler, Stolze, Sanford Moss, Lemale, Armengaud, Holzwarth, Rateau, Stodola, Meyer, and others, a list which emphasises the extent to which the modern gas turbine is the product of international efforts. Only during the last fifty years, however, and particularly during the last twenty years, has the gas turbine evolved—from the intuitions of inventors, the theses of scientists, experimental investigations, the research activity of metallurgists, and the courage and enthusiasm of enterprising manufacturers—into a machine of such versatility as is opening a way for it into all fields of industry. Just what part will be played by the gas turbine during the second half of the twentieth century depends upon factors which are as yet unpredictable. Much will depend upon the success or otherwise of attempts to make it utilise gases at really high temperatures. But we can certainly affirm that formidable as are some of the problems to be solved, there was never a time when the development of a prime mover was supported by so powerful an aggregate of research facilities and by international manufacturing enterprise of such scope and vigour.

TEACHING SCIENCE IN SCHOOLS

Ever since the war revealed the lack of scientifically trained people in this country there has been an outcry of politicians and scientists, and of industrialists, themselves, that industry should make better use of scientific knowledge and employ a greater proportion of science graduates. Under the influence of that preaching and, at least as much, under the stress of the real need they have felt since the war for more staff trained in science, industries have set up an insistent demand for more graduates, and have offered attractive terms of employment. Concurrently the universities, recognising the existence of the demand have successfully and greatly increased their capacities. But it has been overlooked by many unused to educational problems, and not least by many of those who have been most vocal in preaching that if Britain is to prosper more use must be made of science graduates in industry, that training in science is begun long before a student enters a university. Nor is that all. Each year there is a very big entry of lads direct from school into industry, and the brighter of those lads, not less than 100,000 or so, are regularly released by industrial firms to attend classes at technical colleges. They need, just as undergraduates need, a good grounding in the principles of

science whilst at school. It is obvious enough that in grammar schools and public schools alike the quality of science teaching should be high if the nation's needs are to be met. But unfortunately needs and the satisfaction of needs do not necessarily go hand in hand. As a conference organised at the Institution of Electrical Engineers by the Federation of British Industries revealed a week or two ago, the schools are finding it impossible adequately to play their part in giving sufficient numbers of pupils a satisfactory grounding in science. For they are suffering from a shortage of properly qualified teachers.

At the conference Dr. Barton, Headmaster of the City of London School and a member of the National Advisory Council on the Training and Supply of Teachers, gave some disturbing facts about the teaching of science in schools. Before the war there was no difficulty in obtaining an adequate supply of teachers. But a post-war inquiry in 1950 directed to about four-fifths of all the public schools and grammar schools in the country employing some 3065 science teachers revealed not only that 193 posts could not be filled, but, worse still, that as many as 20 per cent of the teachers were regarded as not properly qualified for their jobs. In 1953 a similar inquiry covering rather more than half the schools showed 115 posts still unfilled, about 10 per cent of teachers to be non-graduates or arts graduates teaching science and no less than 84 examples of subjects of study dropped out of a curriculum for lack of a teacher. Nor do those figures reveal the full seriousness of the position. Much teaching of science is only being continued through makeshift arrangements whereby teachers continue in harness after reaching retiring age, others do the work as a part-time job, and headmasters do more teaching than they really should. Moreover, it is undoubtedly a worrying fact that during the last ten years 975 science teachers have left the schools to go into administration or into industry, the latter movement one "almost unheard of before the war." Even leading schools have sometimes since the war been compelled to accept science teachers of low academic qualifications, poor teaching ability and indifferent personal qualifications. This shortage of qualified men is not, of course, confined to the schools. Such men are in high demand in industry and in the scientific civil service which has greatly expanded since the war. But the hope cannot be sanguine that it could be rectified by yet further expanding the university output of graduates. For as Sir Charles Morris, Vice-Chancellor of the University of Leeds, pointed out, doubling the university output has increased the output of really first-class men by only 10 per cent and of good second-class men (a very valuable group) by only 40 per cent. Clearly a law of diminishing returns applies. The better hope would be to attract to science a proportion of the better quality material that at present studies the arts. But if a change of that character is to come about there is all the more need for high-quality teachers of science in the schools capable of developing the interests of pupils in science and technology.

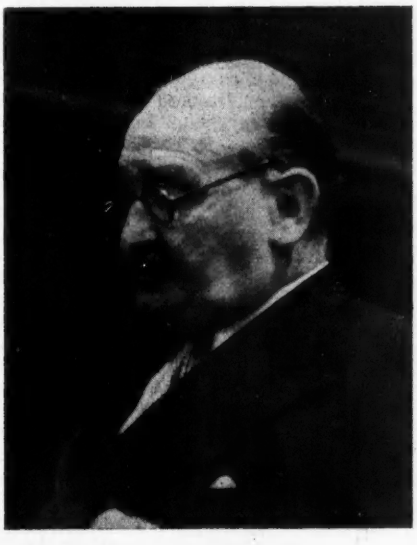
It may be asked why the shortage of science teachers should be singled out for special attention when there is in fact a general shortage in the country of men scientifically trained. The reason was given by Dr. Barton. If the shortage is allowed to persist a kind of deflationary spiral could be created. Too few and inadequately qualified teachers might prove able to train too few pupils to standards high enough for university entry (not to speak of providing a low standard of knowledge of scientific principles amongst lads entering industry direct). Too few scientific graduates then leaving universities would exacerbate the shortage and still further reduce the already inadequate number of teachers in schools. It is, in fact, essentially true that if a community wishes to raise its general standards of attainment in any subject, it must first of all concentrate upon an adequate supply of those who can teach it. By contrast, to-day, industry is offering such much more attractive terms to scientists that the teaching of science in schools is tending to be left to men not really fitted to do it and the better men from the universities are not going into the schools at all. Dr. Barton had a number of remedies to suggest, amongst them the making of research facilities available to school teachers, the more frequent appointment of science masters to headships, deferment from national service for science graduates taking up school teaching, and the fostering by the universities of honours courses in a group of three subjects, two scientific and one arts, with the object of producing science teachers with a broader knowledge of humanity. But basically, so it seems to us, the matter is one of pay. In 1938 the pay of good science teachers, in relation to the kind of life they lead, was comparable with what they could get in other occupations open to them. To-day it is not.

Obituary

E. J. FOX

WE record with regret the death of Mr. Edmund John Fox, which occurred at Tunbridge Wells on January 18th. Mr. Fox, who was in his eightieth year, was for many years the managing director of the Stanton Ironworks Company, Ltd., Stanton, Nottingham.

Edmund John Fox was born on April 21, 1874, and was educated at Rugby School and at the Nottingham Technical College. His engineering training began in the works of Edmonds Copper Company, at Leeds, and later he served an apprenticeship with Crompton and Co., Ltd., Chelmsford. Upon its completion, in 1894, Mr. Fox was given an appointment on the engineering staff of Crompton and Co., Ltd., in which he continued for the following six years. In 1901, he joined Willans and Robinson, Ltd., at Rugby, as an engineer representative. Mr. Fox's association with the Stanton Ironworks Company, Ltd., began in 1917, when he was appointed managing director of the firm. During his twenty-five years in that office he devoted much of his energy to the progressive development of the spun process for the manufacture of iron pipes, a method which is now regularly employed for making iron pipes in diameters up to 27in. He retired from the Stanton Ironworks Company, Ltd., in June, 1942. For a time, Mr. Fox served on the boards of Stewarts and Lloyds, Ltd., and Crompton Parkinson, Ltd., and he was also chairman of Davy and United Engineering Company, Ltd. He was elected chairman of this last-mentioned company in 1931 and remained in office until he reached the age of seventy in 1944. He continued to serve on the board of the company until last year.



E. J. Fox

Mr. Fox had been a member of the Institution of Mechanical Engineers for more than fifty years, and was also a member of the Iron and Steel Institute, on the council of which he served for a number of years. In addition, he was keenly interested in the work of the Institute of British Foundrymen. He was the donor, in 1936, of a sum of money to that Institute, from which the E. J. Fox Medal is presented annually in recognition of outstanding work in the field of foundry metallurgy. For a long period of years Mr. Fox took part in the work of the St. John Ambulance Brigade, and was a Serving Brother of the Order of St. John of Jerusalem.

Literature

Railway Commercial Practice. By H. F. SANDERSON. London : Chapman and Hall, Ltd., 37, Essex Street W.C.2. Price Vol. 1, 25s.; Vol. 2, 30s.

AT one time it may have been that engineers were little, if at all, concerned with commercial practice, either on railways or anywhere else. But the exigencies of the present day, and the tendency for the accountant to assume an increasingly large influence in the conduct of affairs hitherto considered as strictly the province of the engineer, makes it necessary for all engineers and particularly senior engineer executives to be fully aware of all commercial aspects of their respective commands. The author of these two comprehensive volumes is well qualified to deal with his subject, since he is one of the very few railway officers with the benefit of district experience in both the operating and the commercial fields. His first volume which deals with such matters as public requirements; train services; coaching stock—from the commercial viewpoint; fares; office methods, is likely to be of less direct interest to engineers than his second, which is concerned exclusively with freight. In such subjects as the transport requirements for agriculture and industry, the planning of goods train services, goods terminal station working, freight traffic regulations, siding schemes, and so on, he sketches in the background to many of the problems set to railway engineers, such as to provide increased line capacity, higher speeds, quicker working in stations and yards, and the faster transport

of all kinds of freight without damage from rough shunts, harsh braking, and bad-riding vehicles. To all those engineers who have dealings with railways these two volumes should prove of considerable interest and value for reference purposes.

High-Voltage A.C. Circuit-Breakers. By S. GERSZONOWICZ. London: Constable and Co., Ltd., 10, Orange Street, W.C.2. Price 63s.

THE commissioning of new power stations and the growth and interconnection of networks in various parts of the world is causing electric circuit-breakers to play a more and more important role in safeguarding the vital sources of supply and in controlling the distribution of their outputs.

Circuit-breakers have to be built to interrupt currents of many thousands of amperes, at many thousands of volts, and their design, construction and proper use involves the solution of numerous highly technical problems. Professor Gerszonowicz has written an excellent, well-illustrated and thought-provoking book. Although the book is stated to have been written primarily for the user, it contains much of interest to engineers concerned with the design, testing and selection of circuit-breakers and to those dealing with the drafting and revision of standard specifications, and also to the advanced student.

The author has developed his subject in accordance with a logical plan. He starts first with chapters on the basic phenomena underlying and entering into the operation of circuit-breakers; he then describes various types of breakers and studies operation and testing. This is followed by a useful and critical study of national standard specifications. His final chapter is devoted to the important question of the selection of breakers. There is a comprehensive bibliography which will no doubt be added to in the second edition when reference could be made to a few other useful papers which appear to have been overlooked.

The first part deals with over-currents and their effects; a.c. interruption; insulation; study of the arc, and circuit-breaker classification. There is quite a lot of mathematics in this portion and the reviewer's chief criticism of the book arises in this connection. It is, that the author has given no easily consulted list of symbols and their meaning, and it is difficult to follow the development of his argument in some places; for example, in the portion at the beginning of Chapter II where his calculations lead him to suggest the presence of a small negative loop at the start of a restriking voltage transient. One hopes that this difficulty will be smoothed out in the next edition.

The second portion of the book deals with the study of the basic components common to various types of circuit-breakers and these are well illustrated by a series of simplified thumb-nail sketches. It then deals with two widely used types, namely, oil circuit-breakers with plain break and those with controlled break by which, in general, the author means breakers in which the arc is controlled by being drawn inside an inner chamber. He then deals with types of breaker which in general have no bushings but consist of extinguishing chambers mounted on insulating supports, utilising oil, water, air blast, magnetic blow-out or "hard gas" as the arc rupturing agency. Where oil is used such breakers are usually known as "small volume oil" or "oil poor" circuit-breakers. Next circuit-breaker control, automatic reclosing and circuit-breaker testing are dealt with. The section on testing has informative discussions on various methods of obtaining the effect of a full scale test in cases where the test plant is not large enough to provide the required short circuit current at the full rated voltage of the breaker to be tested. This is a condition of affairs likely to become more and more common as the size of national networks increases. For example, in the U.S.A., breakers capable of handling 25,000,000kVA are now being called for—a rupturing capacity many times greater than can be provided wholly by even the most up-to-date test station.

The third part of the book is a very useful contribution; in it the author reviews the specifications governing the performance of circuit-breakers under normal and short circuit conditions of operation. It is unfortunate but unavoidable that the work was published just too early to be able to take into account the revised British Standard 116 of 1952. In this portion he goes on to discuss the vexed question of the influence of the direct component of the breaking current on the breaking capacity and comes to a conclusion, which the reviewer feels is correct, namely, that it is probable that the influence of the direct component varies with the type of breaker. The subject is one of great interest and there is much scope for further investigation.

He concludes this part by a survey of standards relative to temperature rise tests, insulation clearances, and dielectric tests, breaking and making capacities, short time currents and mechanical endurance tests, and finally with a chapter on operating mechanism standards. In the course of the whole review of standards he makes a number of suggestions as to their improvement which might well be studied by those engaged in the revision of standards or the drafting of new ones. The reviewer suggests that the definition of "transient recovery voltage" or "restriking voltage," on page 328, proposed by the author, is inadequate as it should clearly state (see foot of page 54) that it includes the after effects of arcing as distinct from "circuit transient recovery voltage" (or inherent restriking voltage), which latter would be recorded by a restriking voltage indicator connected across the open circuit-breaker on no load.

Turning ahead for a moment to page 414, 9B, the reviewer feels strongly that "circuit transient recovery voltage" (or inherent restriking voltage) is a fundamental quantity which should be quoted in connection with circuit-breaker positions in networks, if information of this type is called for, since if "transient recovery voltage" alone is referred to, this is a quantity which suffers from the after effects of arcing and will vary from test to test. The definition of rate of rise of "inherent restriking voltage" and the definition of its method of measurement are important first steps in order that all who are working on the subject can know exactly what is meant. The next step will be to discover what effort different types of breaker have to make in dealing with given rates of rise of "inherent restriking voltage" in both single and multi-frequency circuits when r.m.s. current, voltage, &c., is kept constant. This is an important and wide field for research. It is mentioned at the foot of page 89 that different efforts are required and also at the top of page 415, where it is stated that air blast breakers without damping resistances are particularly sensitive to transient recovery voltage. The reviewer suggests that the author's exposition would be clearer if the word "inherent" or else the word "circuit" could be used before the words "transient recovery voltage" wherever necessary in the book.

Apart from the bibliography, already referred to, the concluding chapter has much useful advice on matters to be considered when selecting circuit-breakers, and it is pointed out that the few troubles experienced with circuit-breakers are usually traceable to initial mistakes in selection for use rather than in the circuit-breakers themselves.

An index is essential to a book of this type, but trial dips into this one indicate that it could be improved. For example, there is no direct reference to the important question of temperature of arc gas although the reference to this is found if one looks under the word "pressure."

The last words on such an excellent book must not be ones of minor criticism: the book is so full of good things that it should be on the shelves of everyone interested in circuit-breakers and circuit-breaking.

SHORT NOTICES

The Motor Vehicle. By K. Newton and W. Steeds. Fifth edition. London: Iliffe and Sons, Ltd., Dorset House, Stamford Street, S.E.1. Price 35s.—Since its original publication in 1929, *The Motor Vehicle* has become well established as a useful textbook for students of automobile engineering, salesmen, owner-drivers and others connected with the mechanical side of motor vehicles. This well-illustrated book deals with both petrol and diesel automobile engines, gearboxes and other transmission components, and, further, with suspensions, axles, steering and chassis details. The text uses non-technical language as far as possible and mathematics have been largely excluded. The new edition brings the book up to date, new material being provided in the chapters on fuels, carburettors, gearboxes, and torque converters.

Gas Turbines and Their Problems. By Hayne Constant. London: G. G. Harrap and Co., Ltd., 182, High Holborn, W.C.1. Price 17s. 6d.—The first edition of this book by the Director of the National Gas Turbine Establishment appeared in 1948. Since that time gas turbine development has proceeded at a steady, though not spectacular, pace, and in this second edition of his book the author has revised the text to bring his information up to date and in places to make it a little more complete. The chapter dealing with the present position of the gas turbine has been largely rewritten, and a number of more recent illustrations have been added; the remaining alterations and additions are mostly of a minor nature. The book remains a well-written and very readable account of the development and present position of the gas turbine, designed primarily for engineers with no prior knowledge of the subject. There is a complete absence of mathematics, explanations being given entirely in physical terms. In view of his position, Mr. Constant naturally speaks with authority. Throughout the book the emphasis is on underlying principles of operation rather than constructional details. The book is generally of a popular nature.

BOOKS RECEIVED

British Industries: Oil. London: Cassell and Co., Ltd., 37/38, St. Andrew's Hill, E.C.4. Price 8s. 6d.

Microwave Lenses. By J. Brown. London: Methuen and Co., Ltd., 36, Essex Street, W.C.2. Price 8s. 6d.

Elements of Heat Treatment. By George M. Enos. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 40s.

50–100 *Binomial Tables.* By Harry G. Romig. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 32s.

Choice of Careers. New Series No. 42: *The Coppersmith.* Prepared by the Ministry of Labour and National Service and the Central Office of Information. London: Her Majesty's Stationery Office, York House, Kingsway, W.C.2. Price 1s. 3d.

Letters to the Editor

We do not hold ourselves responsible for the opinions of our correspondents.)

PROPER STUDY OF MANKIND

SIR,—I was greatly interested to read your editorial reflections under the heading "Proper Study of Mankind" in your issue of January 8th. From attendance at lectures on training for management, a few years ago, I gathered the impression that the lecturers were well-meaning, enthusiastic individuals endeavouring to impose their grandiose theories upon somewhat sceptical industrialists. It is therefore reassuring to learn that industry has now realised the paramount importance of trained leadership and is prepared to shoulder some responsibility in the matter.

Your pertinent observations on the more fundamental issue of the practicability of teaching the technique of management are bound to evoke contradictory responses from the older school of industrialists. Tradition dies hard. The study of human relations which has engaged your attention has now reached a stage where the findings of the psychologists can provide reliable data for an empirical science. Yet I am reminded of an utterance of a former lecturer who contended that every supervisor of men should have a course in philosophy. I am pleased to note that this sage counsel is implicit in much of your writing. Prejudiced thinking and the subconscious automatic emotional response are largely responsible for the failure to create the team spirit in industry. Recent clashes of managements and workers would seem to indicate that we have much to learn—yet learn we must.

Rugby, January 12th. S. C. MCKENZIE

WALSCHAERTS VALVE GEAR

SIR,—Your reviewer, when dealing with Ahrons' great work on *Locomotive and Train Working*, has repeated the mistake made by the author in giving credit to the predecessor of the Midland and South Western Junction Railway for owning the first locomotive in this country to have Walschaerts valve gear. The distinction rightly belongs to the East and West Junction Railway, which in 1873 acquired a 0-6-6-0 Fairlie locomotive with this gear from the Yorkshire Engine Company. The engine, which had 16in by 20in cylinders and 3ft 6in coupled wheels, had been built for Mexico, but was left on the builder's hands. Whereas two firemen were necessary on this type of engine, when fireholes were provided on opposite sides of the firebox, a peculiarity of the operation of the E. and W.J.R. engine was that, in addition to the firemen, it was always manned by two drivers. Its crew of four probably constituted a record in the number of enginemen required to handle one locomotive.

C. R. H. SIMPSON

London, S.W.1, January 23rd.

WAGES

SIR,—Many minds are endeavouring to find a satisfactory solution to the various wage claims at the present time and, unless commonsense has some measure of success, the future is indeed precarious. May I, therefore, Sir, without taking sides, present a point of view concerning the argument that wages should be raised because the cost-of-living index has risen.

If everyone in industry decided to produce half as much and, in consequence, the cost-of-living index doubled, should wages be doubled or halved? If, on the other hand, everyone in industry doubled their output and, assuming no monetary change, the cost-of-living index therefore fell, should wages be decreased or increased? Strangely enough, apart from those who are paid by results, the wage policy over the years would seem to be diametrically opposed to what commonsense suggests. If fundamental thinking is unsound, what chance is there for satisfactory results?

ANTONY VICKERS

Isleworth, Middlesex, January 25th.

British Electricity Supply System

IT may be recalled that a team representing the electricity supply industry of the U.S.A. visited Great Britain in 1952, as a result of which a report on the British electricity system was published in April, 1953, by the British Productivity Council. Abstracts from the report appeared in our issues dated May 1 and May 8, 1953.

A booklet has recently been issued by the British Electricity Authority containing comments on this report, made by the Authority, the Area Boards and the National Joint Advisory Council of the Electricity Supply Industry. The following abstract from the B.E.A. booklet gives a summary of the principal recommendations made in the productivity report and of the comments thereon.

Recommendation 1.—Liberalise the concept of equipment loadings, with due regard to emergency ratings, to realise greater use of present equipment.

Comment.—Because of the shortage of generating plant since the war, any capacity in excess of the rated value has had to be used by sheer force of circumstances. As regards transmission and distribution equipment, the loading of cables, transformers and switchgear is increased where practicable and is under active review, and further consideration will be given to the emergency ratings of lower voltage overhead lines.

Recommendation 2.—Change the boiler inspection law, thereby increasing boiler availability by approximately 3 per cent.

Comment.—The present boiler inspection law, which is designed to ensure the safety of plant and of operating staff, calls for less frequent inspections for certain types of modern boilers than were required pre-war. For modern boiler plant longer periods between inspections might be justified; but meanwhile the Authority is first obtaining experience of the present arrangements.

Recommendation 3.—Speed up the procedures for obtaining approvals on new sites for steam power plants.

Comment.—The recommendation is endorsed, but for reasons other than those advanced in the report. There is a strong case for a critical scrutiny of existing statutory restraints; but even within the present regulatory framework much could be done, by the authorities concerned, to simplify and speed procedures.

Recommendation 4.—Specify larger turbo-generators of the order of 150MW to 200MW, matching these with single boilers.

Comment.—In order to avoid delay and possible difficulties with entirely new designs, the urgently needed plant installed in the early post-war years was of pre-war design or represented moderate advances on pre-war practice. The programmes for 1955–60, however, include an increasing number of large turbo-alternators, with single boilers, and attention is being directed to 180MW sets with single boilers which will operate satisfactorily on the inferior types of coal allocated to the supply industry in this country. The average size of sets ordered in America in 1952 for normal public supply purposes was similar to that of the sets in the plant programmes prepared in this country during the same period.

Recommendation 5.—Lengthen the period between turbo-generator overhauls from three years to four or five years.

Comment.—The present period between overhauls averages about three years and is increasing. Turbines should be kept in service until there is evidence of some abnormality as shown by unusual vibration, loss of efficiency, &c. Due to the lack of the necessary instrumentation this is not possible with many existing machines, but it should be possible with new sets of 60MW and upwards, which are being provided with full supervisory equipment.

Recommendation 6.—Utilise the unused inherent capability of present lines and equipment by the installation, at suitable locations, of power-factor corrective and control equipment.

Comment.—In this country power stations are available to generate economically the reactive kVA required locally at the load centres, and the main transmission lines are operated at a high power factor. In many respects American conditions are different, and both the necessity for and the economics of reactive compensation on the British supply system are not as clear-cut as the report suggests. Future policy will depend on the findings of a joint committee set up by the Authority and Area Boards some two years ago to investigate this problem.

Recommendation 7.—Simplify substation designs so as to require smaller investments.

Comment.—It is not considered that significant reductions of auxiliary equipment could be made either in Grid substations or distribution substations without detriment to the efficient operation of the supply system. Every consideration is given to simplification of design and equipment of new substations.

Recommendation 8.—Install customer meters on the outside of new buildings and, wherever feasible, relocate on the outside meters installed on the inside of older buildings.

Comment.—Climatic and safety conditions in Britain are unfavourable to the general adoption of outdoor metering, and the additional cost of designing or protecting the meters for use out of doors would generally exceed economies achieved by any increased rate of meter reading which might result. It would not be satisfactory to place pre-payment meters out of doors.

Recommendation 9.—Allocate more funds for the development and promotion of rural electrification.

Comment.—Despite imposed limitations, there has been a substantial increase in the number of farm connections since vesting day. Since the report was published, the Government has decided to increase the industry's capital investment allocation to permit additional expenditure on rural electrification, and the ban on promotional publicity has been relaxed.

Recommendation 10.—Provide for a greater differential in wage-scales between lower and higher skilled workers, to give increased recognition to the value of skills.

Comment.—The situation has been complicated by the reduction of differentials during and since the war due to flat-rate wage increases. Restoration of the differentials has not proved feasible, but some adjustment has been made.

Recommendation 11.—Educate members of trade unions on the need for increased productivity to raise the workers' standard of living.

Comment.—Much work has already been done in this direction. There has been considerable discussion within the joint advisory machinery on matters affecting efficiency and productivity.

Recommendation 12.—Utilise technical personnel, both non-university and university graduates, more efficiently.

Comment.—This recommendation does not appear to be adequately supported in the body of the report. The majority of technical posts are filled by men who have come up through the industry and have obtained their qualifications by part-time study. Considerable education and training facilities are now available.

Unqualified men with good practical experience are employed in minor supervisory posts wherever practicable.

Recommendation 13.—Consolidate, in each area, duplicating purchasing functions of Divisions and Area Boards.

Comment.—This suggestion has been examined on more than one occasion. Only a small proportion of local purchases and stores are of kinds common to Boards and Divisions, and it is thought that existing arrangements, which are reviewed from time to time, are on balance the most economical.

Recommendation 14.—Provide closer timing on deliveries of equipment and materials to construction jobs.

Comment.—Progress is checked by the Authority's engineers in main manufacturers' works at least every four weeks and more frequently if necessary, and this is considered satisfactory having regard to the manpower problem. Under the Authority's arrangements, shortages can be foreseen and remedial action taken.

2400 h.p. Main Line Electric Locomotive for Victoria

Twenty-five 2400 h.p., 1500V, d.c. mixed traffic C_0–C_0 locomotives are being built by the English Electric Company, Ltd., for service on the Gippsland main line which is being equipped for electric traction from Melbourne to Traralgon, a distance of 97½ miles. It is the first section of main line railway in Australia to be electrically operated. The locomotives have rheostatic braking.

ELECTRIFICATION of the Gippsland line from Melbourne to Traralgon is an outcome of the recent expansion of the brown coal industry in Victoria. Whereas the coal traffic on this line was 980,000 tons in 1948–49, it is expected to reach 1,760,000 tons in 1958. Until recently the line was single tracked beyond Dandenong, 18 miles from Melbourne; then in 1952 double-track working was introduced in the 18-mile section between Longwarry and Yarragon. Further improvements of this kind would have provided increased traffic capacity with steam operation, but it was considered that the required increase could be achieved more economically by the introduction of electric traction.

East-bound freight trains of 550 tons weight will be operated by a single electric locomotive (Fig. 1), capable of sustaining 30 m.p.h. against the 1 in 50 ruling gradients facing east-bound trains. West-bound loaded mineral trains weighing 1100 tons will be hauled by two electric locomotives over the first 8 miles from Morwell to Moe, where the ruling gradient is 1 in 50 and by one locomotive over the 81 miles from Moe to Melbourne. The ruling gradient facing west-bound trains between Moe and Melbourne is 1 in 110 and one electric locomotive will haul 1100-ton trains at 30 m.p.h. against this gradient.

The introduction of electric working between Melbourne and Traralgon will enable the running times of freight and passenger trains to be reduced substantially, compared with existing timings for steam operation, as shown in Table I.

The substantial reductions expected in running times with electric traction are attributable to improved locomotive performance during acceleration and on rising gradients and to the use of rheostatic braking, which enables freight trains to descend lengthy and steep gradients without the imposition of speed restrictions to prevent overheating of brake blocks and tyres. Using rheostatic braking alone one locomotive can, it is stated, hold down the speed of a 1100-ton mineral train to 35 m.p.h. on a 1 in 50 gradient.

The leading dimensions and particulars of the locomotive are given in Table II. The locomotive performance characteristics are shown in Fig. 3 and rheostatic braking curves are reproduced in Fig. 2.

TABLE I—*Comparison Between Electric and Steam Train Timings*

Section	Service	Load, tons	Distance, miles	Steam timing	Electric timing (estimated)
Melbourne–Traralgon	Passenger	275	97½	190 min	130 min
Traralgon–Melbourne	Passenger	275			
Melbourne–Morwell	Through freight	550	89	300 min	200 min
Morwell–Melbourne	Through freight	1100	89	350 min	230 min

Mechanical Parts

The underframe and superstructure are designed as a welded, single-unit, stress-bearing structure. The dragboxes are welded structures, heavily gusseted to withstand severe service; the sheet steel superstructure panelling is welded to the framing members. The roof sections carrying the pantographs are formed into a well and are removable to permit installation of the control equipment. Removable chequered floor plates are provided in the gangway of the equipment compartment and provide access to cabling and conduit runs.

TABLE II—*Principal Dimensions and Particulars of Locomotive*

Track gauge	5ft 3in
Length over couplers	60ft 10in
Overall width	9ft 3in
Overall height (pantograph housed)	13ft 9in
Total wheelbase	46ft 4in
Rigid wheelbase (bogie)	14ft 4in
Wheel diameter (new)	40in
Weight in working order (adhesive)	96 tons
Motors (six): one-hour weak-field rating	400 h.p.
Maximum tractive effort (25 per cent adhesion)	54,000 lb
Maximum axle loading	16·25 tons
One-hour tractive effort (full field) at 29·5 m.p.h.	28,700 lb
Maximum rheostatic braking effort at 35 m.p.h.	44,000 lb
Continuous tractive effort (full field) at 30·4 m.p.h.	25,200 lb
Maximum service speed	75 m.p.h.

The three-axle bogies (Fig. 4), which are suitable for conversion to 4ft 8½in gauge, are non-articulated, the tractive forces from each bogie being transmitted to the draw gear through the centre pivots and underframe structure. A nose-suspended traction motor is mounted on each axle. The bogies are of double-swing bolster design and are fitted with drop type, equalising beams. Springing is provided by the elliptical laminated bolster springs and coil springs to the equalising beams.

From the locomotive superstructure the load is transferred to each bogie, through a centre bolster casting, to four laminated semi-elliptic spring groups which are carried on spring planks suspended from the bogie transoms by four pairs of inclined swing links.

The lower member of each bogie centre casting is spigoted and welded to the bolster beam, whilst the upper member is spigoted and bolted to the underframe transom. The bogie frame is a fabricated structure jig built to close limits. The drop type equalising beams, which are of forged steel, are located on top of the axleboxes; with this arrangement the coil and elliptic springs can be inspected readily and the wheel sets can be lowered for removal without disturbing the beam and spring gear. The axlebox journals are fitted with roller bearings in cast steel housings. The driving and lateral thrust faces of the axleboxes, also the respective members on the bogie frame, are fitted with manganese steel liners.

Four air brake cylinders are mounted on each bogie, above the axle gaps at the outer ends of the frame. Each cylinder operates clasp brakes on the adjacent wheel and one brake block of the centre wheel through appropriate brake rigging. The air brake system provides braking up to 85 per cent of the total weight of the locomotive. A hand brake is also provided.

Control System

The control equipment provides for the following combinations of traction motors:—(1) Series grouping—six motors in series. (2) Series-parallel grouping—two parallel groups of three motors in series. (3) Parallel grouping—three parallel groups of two motors in series.

Three stages of traction motor field weakening are provided. There are forty-two power notches of which twenty-one are in series grouping, twelve in series-parallel grouping and nine in parallel grouping. Three weak-field running notches and a full field running notch, in which there is no resistance in circuit, are obtainable in each motor grouping. There are, therefore, a total of twelve running notches which may be utilised continuously.

Rheostatic electric braking is obtained by separately exciting the traction motor fields and loading the armatures by current flow through resistors. This arrangement, which is not materially affected by variations in line voltage, gives effective braking over a wide range of train speeds without affecting traction sub-station equipment.

The power supply is taken from the overhead line through one of two pantographs via pantograph- and equipment-isolating switches. Contactors insert or cut out steps of resistance in the traction motor circuits in accordance with the setting of the master controller. Motor grouping, field-weakening and reverser switches are contained in the traction motor circuits. The motor grouping switches are electrically interlocked with the resistance contactors to ensure that the power circuit is interrupted only by the line breakers.

Traction Motors

Three axle-hung series-wound, forced-ventilated "EE 519" traction motors are mounted in each bogie of the locomotive. Each motor, which drives its respective axle through single-reduction spur gearing, has a one-hour weak-field rating of 400 h.p., 460A, and a continuous weak-field rating of 360 h.p., 420A at 700V. Each motor is fitted with grease lubricated roller armature bearings with oil-lubricated white metal sleeve bearings for the axle

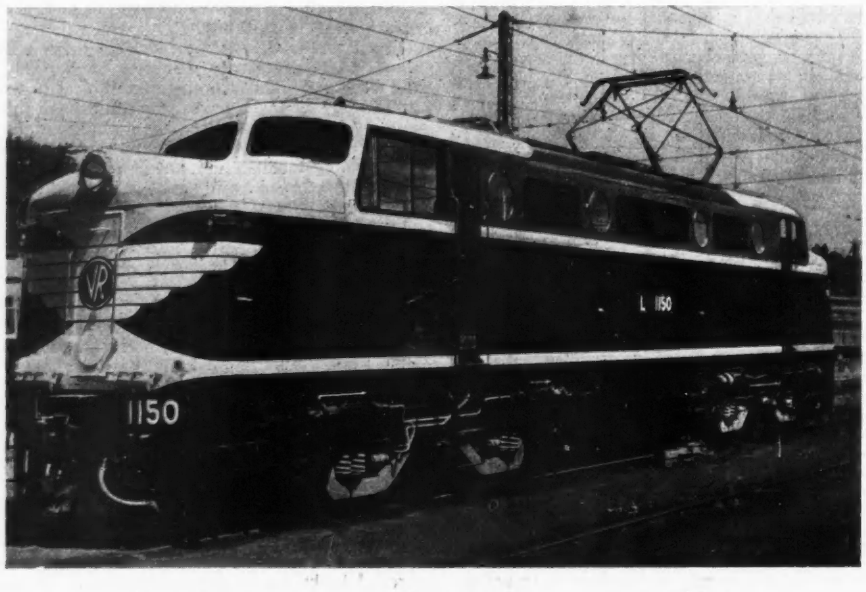


Fig. 1—2400 h.p., 1500V, D.C. Main Line Co-Co Locomotive for Victoria

suspension. The final drive gearing is enclosed in a welded, split, sheet steel gear case which is supported from the motor frame and contains gear lubricant. The pinion is shrunk and keyed on to the motor shaft and the gear wheel, which is pressed on to the axle, is of a rubber-resilient design, allowing a certain amount of torsional resilience between the motor armature and the axle.

In the event of a traction motor failure the pair of motors which includes the defective one may be disconnected by a hand-operated camshaft grouping switch, enabling the locomotive to be operated with four motors in series or in series-parallel grouping.

Control Equipment

In each cab the driving position includes a master controller, air brake and sanding valves and push-button switches for the remote control of pantograph-operating valves and the resetting of tripping relays. The instrument panel includes a speedometer, one motoring ammeter for each pair of traction motors, braking ammeter and duplex air pressure gauges. The instrument panel is provided with rear illumination for night driving. Lamps are mounted on the panel to indicate fault conditions in the operation of the traction motors, traction motor blowers and resistance blowers, and to show the availability of control circuit supply at the appropriate voltage. The cab-mounted equipment includes the low-voltage circuit breakers and switches for the control and protection of lighting circuits, and the recording apparatus for the speedometer. Each cab is provided with two 500W low-voltage convection heaters and a hot plate for food warming.

The master controller incorporates a control wheel, a reverse lever, and a rheostatic brake control lever.

The control wheel has thirty-six positions. They select the thirty resistance notches, and the full-field running notches for each motor grouping, together with intermediate and weak-field notches for use when the motors are in the parallel grouping.

The reverse lever has " Forward," " Reverse," and " Off " positions. It also has control positions to select intermediate and weak-field operation when the traction motors are in the series or series parallel groupings ; these positions are obtainable only when the control wheel is in the " Full Series " or " Full Series Parallel " notches. Removal of the reverser key can only take place in its " Off " position, whilst mechanical interlocking ensures that the control wheel and rheostatic brake control lever are then also locked in the " Off " position. The equipment is thereby protected against unauthorised operation.

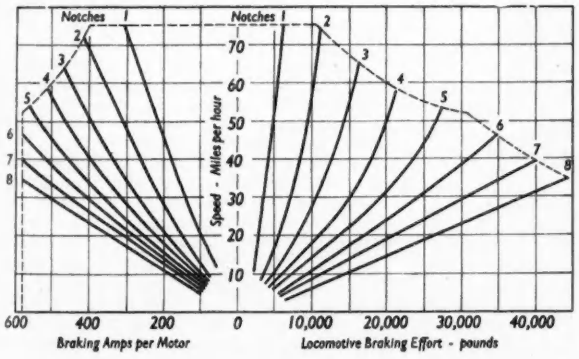


Fig. 2—Locomotive Rheostatic Braking Performance

The rheostatic brake control lever has eight notches which regulate the braking effort (Fig. 2). The brake lever is mechanically interlocked so that it can only be operated when the control wheel is in the " Off " position and the reverse lever is set to the appropriate direction of motion.

Rheostatic Braking

During rheostatic braking the traction motor fields are connected in series and the traction motor armatures in three independent groups, each having two armatures in series. The motor fields are excited from the variable voltage exciter of the three-machine motor-generator set referred to below, and the traction motor armatures are loaded by current flow through resistors. The rheostatic braking effort is regulated by variation in the field strength of the exciter. The amount of current flow through the traction motor fields, being a function of the exciter output, determines the strength of braking effort.

Interlocking is provided between pneumatic and rheostatic braking equipment, such that rheostatic, automatic air braking and straight air braking can be operated as follows :

1. Rheostatic braking on locomotive only with no braking on train.
2. Rheostatic braking on locomotive and automatic air braking on train.
3. Automatic air braking on locomotive and train.
4. Straight air braking on locomotive only.
5. In the event of an emergency air brake application the rheostatic brake on the locomotive, if applied, is rendered inoperative.
6. In the event of failure of the rheostatic brake in the conditions stated in case 2 above, the automatic air brake is applied to the locomotive as well as to the train.

Multiple Unit Operation

Two locomotives coupled and with control wires interconnected may be operated from any driving cab under the control of one driver. In the event of failure of a motor-generator set in one of two locomotives operating in multiple, a low-voltage supply may be taken from the other locomotive, thereby permitting normal operation with the exception of rheostatic braking, which would not be available on the locomotive with the defective motor-generator set.

Layout of Electrical Equipment

The high-voltage control equipment is housed in control frames mounted in the locomotive superstructure. Two of these frames (line breaker and group switch) are installed, one on each side of a central gangway, immediately aft of the driver's cab. The line breaker frame shown in Fig. 5 carries the line breakers, circuit and resistance contactors, overload protection relays and motor cut-out switches. Entry to these high-voltage equipment compartments is made through doors which are interlocked with the air supply to the pantograph ; these doors can be opened only when the pantograph is lowered and the equipment is thus disconnected from the high-voltage supply.

The resistors which serve both for motoring and rheostatic braking are contained in two heat-insulated compartments in the centre of the locomotive superstructure. Forced cooling is provided, each resistor compartment being ventilated by three fans, which blow air over the resistors and expel it through louvred openings in the locomotive roof. Each resistor-ventilating fan has a capacity of 3300 cubic feet at 4in water gauge. The series-wound driving motors for the fans are connected across a section of the resistor, the starting and stopping of the motors and their speed whilst running, therefore, being a function of the load current in the resistors. Under fault conditions indicator lamps in the driving cabs are illuminated.

The double-pan pantographs are raised pneumatically against a spring loading system, the spring extension being controlled by cams to ensure that the contact pressure against the overhead line is substantially constant throughout the height variation range of the overhead line. The pan balancing mechanism is resilient, to accommodate small variations in the alignment of the overhead line.

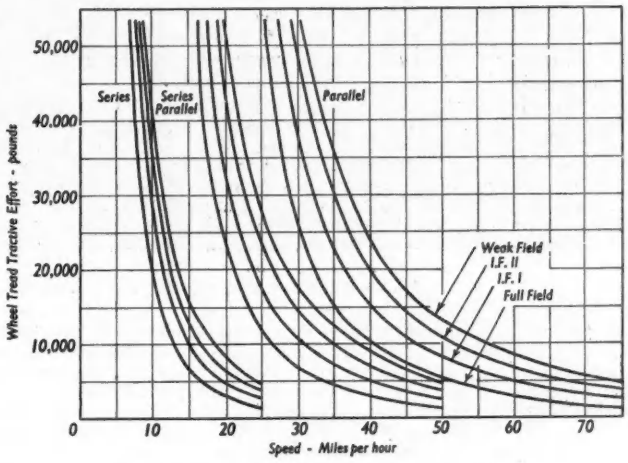


Fig. 3—Locomotive Performance Characteristics

Protection against earth fault or excessive loading during motoring or braking operation is provided by instantaneously tripping relays. These relays operate, first, by opening the line breakers and disconnecting the equipment from the power supply whilst motoring, and, secondly, by cutting off the excitation current to the traction motor fields when rheostatic braking is in use.

The line breakers and one of the resistor contactors are fitted with two magnet valves to provide for " normal " or " high-speed " opening. The high-speed function is selected only by the overload relays, in which condition the line breakers and one of the contactors are sequence controlled to insert a buffer resistance in the fault circuit, thereby limiting the final current flow to be interrupted.

Auxiliary Equipment

Each locomotive is fitted with a three-machine motor-generator set comprising a driving motor, constant-voltage auxiliary generator and variable voltage exciter. Indicator lamps in the driving cabs are connected across the auxiliary generator and indicate whether the set is running or not.

The self-excited auxiliary generator supplies current at 115V for operation of the control equipment, lighting circuits and auxiliary services. The output voltage of the auxiliary generator is maintained at a constant value, at all normal speeds and loads, by a carbon pile voltage regulator. A six-cell lead acid battery is trickle charged from this supply and provides a 12V emergency lighting circuit.

The separately excited variable-voltage machine of the motor-generator set provides field excitation for the traction motors during rheostatic braking.

The 1500V driving motor of the three-machine motor-generator set obtains its supply from the pantograph, through isolating switches, and is controlled by a hand-operated, loose-handle circuit breaker and an electromagnetic contactor which shorts out the starting resistance automatically at a predetermined speed. A protective resistance is permanently connected in the positive supply. The circuit breaker for the driving motor trips instantaneously in the event of a short circuit or earth fault and is fitted with an inverse time lag device to deal with sustained overloads.

Forced ventilation for the traction motors is provided by two motor-driven centrifugal blowers, one being housed in each nose-end

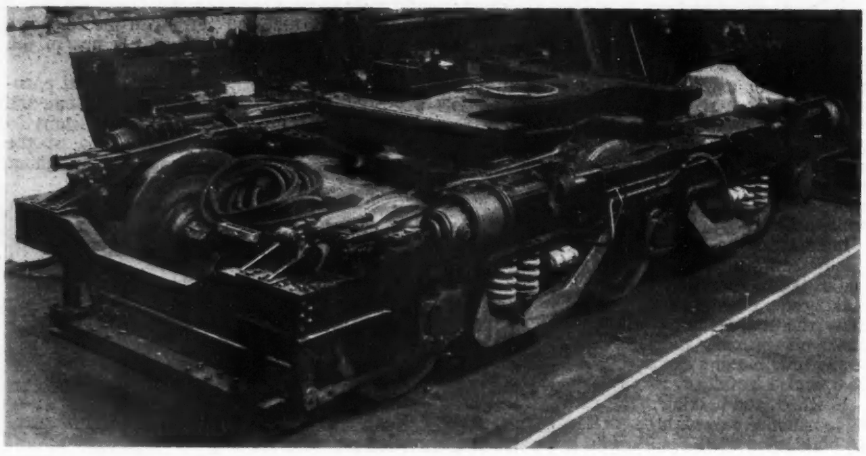


Fig. 4—Bogie with Centre Bolster and Traction Motors

compartment. Each blower draws air through viscous filters mounted in one side of each nose-end compartment and delivers it to the traction motors in the adjacent bogie. Each blower can deliver 6000 cubic feet of air per minute at 4·5in water gauge. Distribution vanes are built into the ducts to the respective traction motor air intakes to ensure that an equal quantity of air is supplied to each traction motor. A small amount of air is bled from each traction motor blower duct to pressurise the nose compartment. The blowers are driven by 1500V motors which receive their supply from the pantograph through isolating switches and protective resistances. They are controlled by hand-operated, loose-handle circuit breakers with time delay and instantaneous tripping devices.

Compressed air for the operation of locomotive and train brakes, sanding valves, pantographs and electro-pneumatic control gear is provided by the operation of two motor-driven, two-stage compressors, one being housed in each nose compartment. Each compressor has a capacity of 75 cubic feet per minute, which is sufficient to meet normal demands, thereby avoiding immobilisation of a locomotive in the event of failure of one compressor set.

The 1500V compressor motors are supplied from the pantograph via isolating switches, a protective resistance and a hand-operated, loose-handle circuit breaker fitted with time delay and instantaneous tripping devices. The motors are controlled by electromagnetic contactors, the contactor operating coils being switched on and off by a pneumatic switch set to maintain air pressure between 85 lb and 100 lb per square inch.

Because of the dirty air conditions experienced in the mining areas through which the locomotives will operate, the air pressure in the equipment compartments is maintained at slightly higher than atmospheric by a motor-driven fan which draws air through viscous filters in the side of the locomotive superstructure at cant rail height. This fan delivers 4000 cubic feet of air per minute at 0·6in water gauge. The filter panels are readily accessible, can be changed from the interior of the locomotive, and are interchangeable with those of the blowers used for forced ventilation of the traction motors. The 115V, series-wound fan motor is connected directly across the auxiliary generator and is protected by a circuit breaker.

The voltage regulator, battery relay and circuit breakers for low-voltage equipment are accommodated in an enclosed cubicle in the locomotive superstructure. The emergency battery is enclosed in a separately ventilated section of this cubicle.

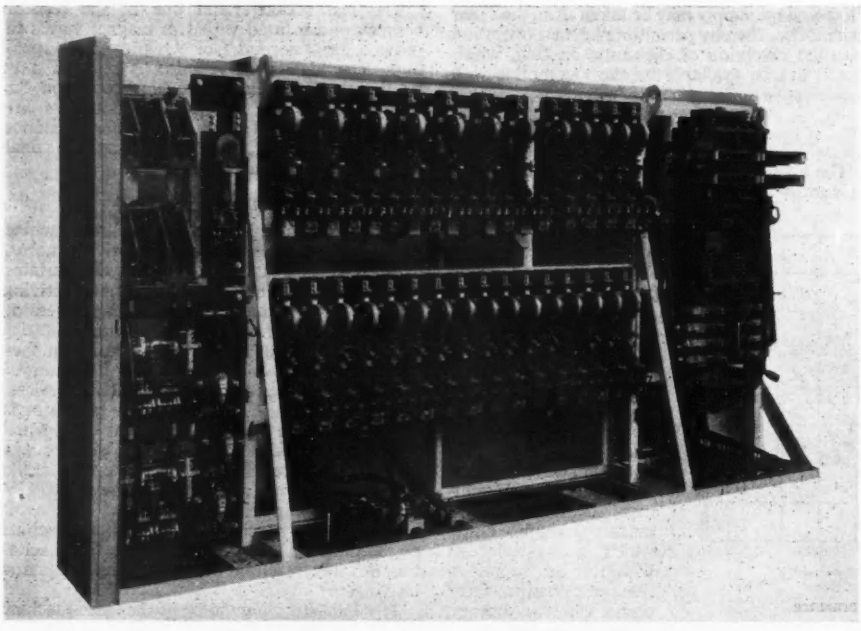


Fig. 5—Line Breaker Frame Showing Circuit and Resistance Contactors, Overload Relays and Motor Cut-out Switches

LEAFLETS ON SOLDERING AND BRAZING.—A series of leaflets has just been published by Grey and Marten, Ltd., City Lead Works, Southwark Bridge, London, S.E.1, dealing with bearing metals, fusible alloys, soft soldering of aluminium, soft soldering, and silver soldering and brazing, with the firm's "Amalgam" materials.

Accident and Fatigue Investigations at Farnborough

DURING the course of a visit to the Royal Aircraft Establishment, Farnborough, last week, we were able to see some representative tests in its structural fatigue investigation programme and to learn something of accident investigation procedure.

Much of the work in hand concerns the particular case of wing structure failure resulting from gust loading.

In the prevention of fatigue failure the first objective is to measure the gusts or bumps that can be experienced in different climates all over the world. In recent years a new instrument called the counting accelerometer has been invented and developed at R.A.E. It is basically a mechanical instrument and not only counts the gusts, but also grades them according to severity. With this instrument all British air routes have been surveyed for practically every British civil aircraft in regular use. From this instrument has been developed an electronic "fatigue meter" sufficiently small that it could be permanently fitted as supplies become available to every individual aircraft. It will then be possible to record each aircraft's life history in terms of bumps.

Fatigue Tests on Components.—The main safeguard against fatigue failure is a limitation on flying life that is rigidly imposed by the Air Registration Board, the aircraft being withdrawn from service after its "safe" life is deemed to have expired. Calculations of life are based upon the gust measurements just mentioned and upon tests of specimens of the actual structures. All the main components, especially joints, of all civil aircraft are fatigue tested to destruction, and the tests are repeated on at least six specimens of each component.

The R.A.E. has two component testing machines in continuous use which are based on the Schenck principle. In each of these machines the reciprocating load is applied by weights vibrating on coil springs. The reciprocating load is superimposed on a steady load corresponding to steady level flight. For all practical purposes the component is loaded as if in flight. One second in these tests is equivalent to about one hour of flight, and it is thus possible to determine the fatigue life early in the operating life of the aircraft. Although work such as this is in hand by most of the aircraft manufacturers the R.A.E. is regarded as the focal centre of this major aspect of the problem.

Fatigue Testing of Wings and Complete Aircraft.—Component testing has, of course, been undertaken for many years, but more recently it has become desirable to establish to what extent the behaviour of the complete assembly, i.e. the wing, *in situ*, accords with that predicted from component testing. Isolated cases of complete wing fatigue tests have been known, but those related to a single specimen of a specific aircraft and the data obtained could not be regarded as being generally applicable even to that particular make of machine.

For the complete analysis of the fatigue life of a full-scale wing would require the testing to destruction of a considerable number of similar structures. Such a programme would be prohibitively expensive, for apart from the space and the specialised load simulation equipment required, the cost of the wing of a modern high-speed civil aircraft can be as high as £200,000.

Consequently, at Farnborough, it was decided to use the tailplane of an aircraft as a small-scale wing and to load it accordingly. The "Meteor" tailplane was chosen and sixty of these units have now been tested to destruction. Two quite different techniques have now been evolved. In the first, which was used on all the "Meteor" units, the wings were made to vibrate, using rotating out-of-balance weights at the wing tips. Exhaustive research was carried out, including tests with a number of wings, on a special rig, at low temperatures. In connection with these latter tests it was established that the fatigue life improved with decreasing temperature. The technique culminated in a similar test on the wings of a "York" aircraft with a span of 110ft.

The difficulties in testing wings of large span—the first fatigue failure in the "York" test was in the

testing rig and not in the aircraft—led to another method which is often preferred. In this the loads are applied by hydraulic rams following an automatic cycle. This method is known as the "slow-loading" method, but the term is relative, since one minute of testing time is equal to about one hour of flight.

The "Comet" aircraft is being tested at R.A.E. at the present time by this method. The aircraft is a worn-out prototype and is not representative of the "Comet" in operational use. Nevertheless, very useful scientific information is being obtained, and the test will continue indefinitely until it is quite beyond repair.

A particularly simple method of loading the wing has been adopted. Weights have been added in the fuselage at the wing roots to make up the fully loaded airborne condition. The loading condition, which has been chosen as the most appropriate for this particular investigation, is that resulting from gusts of 10ft per second. The loading alternates between $\pm 0{\cdot}3$ times the static weight of the machine about its static weight at a rate of 10 cycles per minute. The positive loading is applied by the jacks placed spanwise and the negative loading is achieved by allowing the aircraft to "bottom" partially on its supporting chocks.

Accident Investigation.—On May 2, 1953, "Comet" aircraft G-ALYV crashed near Calcutta with fatal results to all on board. After the formal inquiry by the authorities in India, a large proportion of the parts, collected over an area of many square miles, were sent to the R.A.E. by air. Other parts were sent later on request.

The R.A.E. then began its task of reconstruction which continued for several months. The parts are laid out on the floor of a special hangar, as far as possible in their correct relative positions corresponding to an unbroken aircraft.

The accident investigation in this case followed well-defined lines. The position of every part as it fell on the ground was plotted on a map. From a knowledge of the free fall characteristics of typical parts it was possible to deduce the order in which the parts broke away. Scratches, and dents, and paint marks on the broken parts were then examined for further clues to the sequence of failure. The presence of fire which gutted the main wreckage rendered the task more difficult, but even this was turned to advantage in one respect. To the deductions drawn from dents and scratches was added those derived from blistered paint, burned surfaces and smoke marks.

As a result of this reconstruction and analysis lightning strike and explosion were dismissed as causes of the accident. Fire was shown to be secondary, having occurred following the structural failure and as a result of it. The sequence of failure was also established: first one tailplane then the other, followed shortly by one wing and then the other. The investigation proceeds to try to find what led to these events; no structural weakness in the aircraft has been found, and it therefore seems that either some event occurred which led the aircraft into a very abnormal condition of flight, or that it encountered weather which would have broken any aeroplane.

Diesel-Hydraulic Locomotive for Tasmania

THE diesel-hydraulic locomotive illustrated on this page has recently been completed at the works of the North British Locomotive Company, Ltd., to the design requirements of Mr. F. McCormick, general manager of the Emu Bay Railway, Tasmania, for use as a single unit or in multiple with a second locomotive of the same design. It is powered by a Paxman twelve-cylinder engine with a rating of 530 b.h.p. at 1150 r.p.m., and the transmission unit is of Voith-North British turbo design, with a two-speed range final drive.

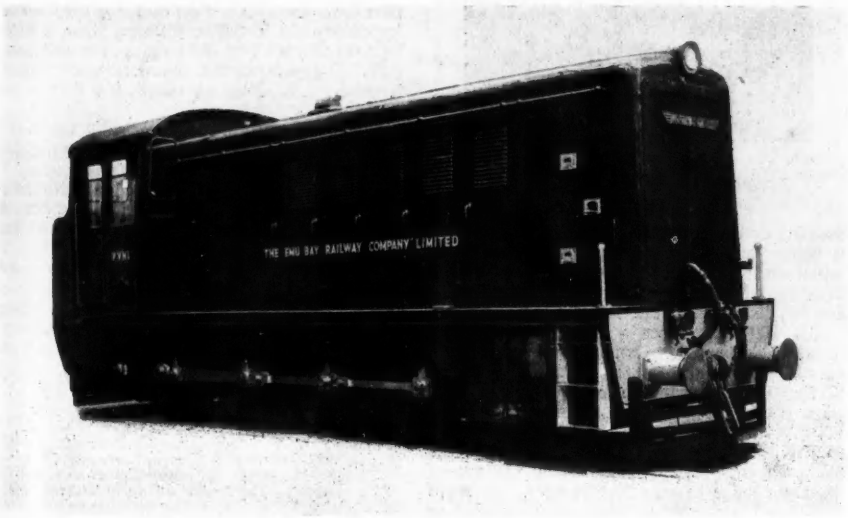
The locomotive is required to haul both passenger and freight trains between Burnie and Rosebery, a distance of 70 miles, rising from 124ft at Burnie up to 2305ft, and then down to 640ft above sea level at Rosebery. The selection of the two speed ranges was made specifically to meet the freight and passenger requirements on the very steeply graded sections of the line, which vary up to 1 in 33. Maximum tractive effort is limited by adhesion and there was little to be gained by bringing the maximum for the lower speed range below 25 m.p.h.

The locomotive is eight coupled 0-8-0 with side control on the leading pair of axles to enable the traversing of small radius curves and also to reduce wear on the wheel flanges. The power to the wheels is transmitted from the jackshaft, which drives the side rods through balanced cranks. The leading dimensions and other particulars are as follows:—

Gauge	3ft 6in
Length over buffers	30ft 6in
Maximum height	11ft 10in
Maximum width	9ft 2in.
Wheelbase	12ft 9in
Wheel diameter	3ft 6in
Total weight, working order	43 tons
Maximum speed, low-speed range	25 m.p.h.
Maximum speed, high-speed range	35 m.p.h.
Fuel oil capacity, main tank	250 gallons
Fuel oil capacity, service tank	65 gallons

The frame is a welded plate structure braced and stayed and the stretchers, brackets and fittings which may have to be removed for dismantling and repairs are secured by fitted bolts. The main laminated bearing springs are compensated in two groups of four wheels each. Timken roller bearings, which are grease lubricated, are mounted on the outside of the wheels, and manganese steel liners are fitted to the axle-boxes and their guides.

The arrangement and design of the power unit, the transmission and control system fitted on this locomotive are generally similar to those on the locomotives built by the company for the Mauritius Railway and described in THE ENGINEER of November 20, 1953.



530 h.p. Diesel-Hydraulic Locomotive

Carbon Dioxide as a Machining Coolant

PARTICULARS have been received of a method which has been developed by the Carbon Dioxide Company, Ltd., Abbey House, Baker Street, London, N.W.1, in conjunction with the Distillers Company, Ltd., for using carbon dioxide as a cutting tool coolant in machining operations. This new technique, which is known under the trade name "CeDeCut," is claimed to be a considerable advance on previous attempts to use carbon dioxide in machining when it was generally tried to use it in a similar way to ordinary coolants.

Before dealing further with the technique it should be recalled that CO_2 is conveniently delivered to a particular machine in the form of a liquid under pressure. The essential importance of liquid CO_2 as a coolant is derived from the fact that, when expansion of the liquid to the atmosphere by flash evaporation converts part of it to gas, the consequent reduction in temperature converts a further proportion to a "snow" of solid CO_2, which, at atmospheric pressure, exists at a temperature of minus 78 deg. Cent. Under these conditions the solid then sublimes directly into gas, and for every pound of solid thus gasified 250 B.Th.U. of heat are removed from the surroundings. It will be appreciated that when, by suitable control of the liquid CO_2, the solid form is produced and projected on to a restricted area of hot surface such as a tool tip, phenomenal rates of heat exchange can be achieved.

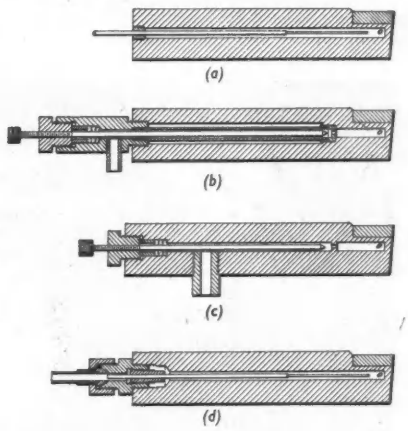


Fig. 1—Lathe Tools Cooled by Carbon Dioxide

In early attempts to utilise the properties of CO_2 for low temperature cooling, jets of liquid CO_2 were directed towards tool cutting and grinding surfaces. It was found that the cold finely divided "snow" cooled everything with which it came into contact, the cooling effect in some cases being sufficient to allow higher rates of machining and to increase the life of the cutting tool. These results suggested that it would be well worth while to investigate the possibilities of using CO_2 as a coolant for some of the metals and alloys and high tensile steels developed in recent years and which have presented difficult machining problems. At the outset of the experiments which were undertaken it was decided to regard CO_2 as a new form of coolant rather than as a substitute for those generally used and which still have a wide field of application.

After preliminary trials it was decided to develop methods whereby CO_2 "snow" would be directed to the tool tip where the cooling effect was most needed and towards the work-piece to keep it cool, but away from turnings or chips where high temperature was desirable. The new technique can best be described as applied to lathes.

Some of the tools successfully developed for applying the cooling technique on lathes are illustrated on this page. In the tool shown in Fig. 2 the CO_2 jet is directed at the leading edge of the tool, only the surplus coolant being allowed to reach the workpiece whilst none at all reaches the chip. Another method makes

use of a tool such as that shown in Fig. 1(*a*), in which a reservoir of coolant is provided under the tip of the tool and access of coolant to the chip is prevented. Any excess coolant is discharged on to the workpiece and assists in maintaining its normal temperature.

With a tool of the kind shown in Fig. 1(*a*) the rate of flow of the CO_2 is normally controlled by the jet or capillary and, in general, it cannot be controlled between the supply and the final restriction in the flow line. An intermediate control would involve the introduction of an orifice of dimensions comparable with those of the jet, and the pressure drop through the controlling orifice would inevitably cause the formation of solid CO_2 between the control valve and the jet. To overcome this difficulty and at the same time provide means for adjustment of flow rates an orifice valve has been designed which can be fitted as a complete unit within a lathe tool or embodied in the shank of the tool. Two tools of such arrangement are shown diagrammatically in Fig. 1 (*b*) and (*c*).

A further modification of the supply system of a lathe tool is shown in Fig. 1 (*d*). In this case the capillary and holder form an integral part of the tool and when it is removed from the

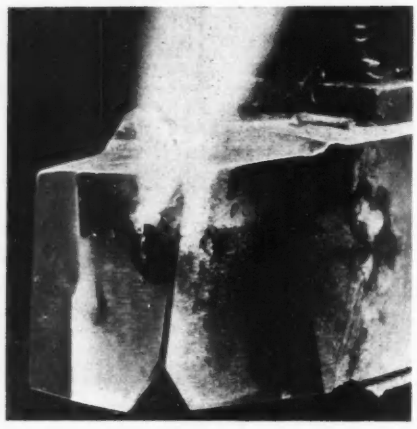


Fig. 2—Carbon Dioxide Cooled Lathe Tool

lathe provides a means of tip cooling by CO_2 during regrinding. An advantage of this design of tool is that all the necessary adjustment of capillary length and all fitting can be carried out in the tool room.

Most of the development work in connection with lathe tools has been with tipped tools but it is pointed out that high-speed tools can readily be adapted by leading the capillary in a groove so as to discharge CO_2 at the cutting edge.

It is pointed out that probably the simplest and most direct field of application for CO_2 coolant is in dry turning, where by the application of carbon dioxide near the tool cutting edge machining speeds can be greatly increased and tool life extended. By using the technique in cases where liquid coolants are normally used a number of advantages in addition to lowering tool tip temperatures and increasing permissible cutting speeds are obtained. The atmosphere is not contaminated by fumes, wearing parts of the machine which are lubricated do not have their lubricants contaminated or washed away, the operator's view is not obstructed by fumes, and cutting conditions are maintained uniform. Methods have also been developed for using CO_2 to good effect as a coolant in drilling, milling, boring, tool tip grinding and other operations with difficult metals.

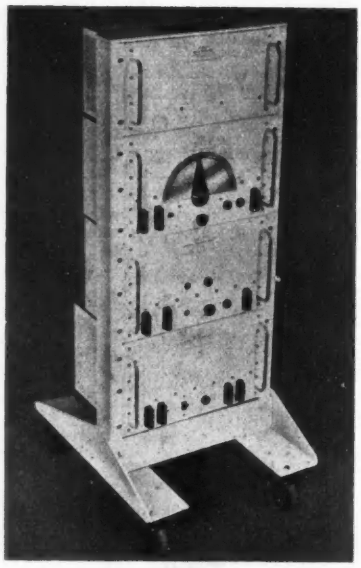
The Carbon Dioxide Company, Ltd., points out that investigations have shown that there is little, if any, chance of harmful concentrations of CO_2 forming in a normally equipped and ventilated shop. It states that although the work so far carried out can only be regarded as a qualitative general survey, noteworthy results are being obtained, and as investigations proceed and experience is gained, the cooling of machine tools by carbon dioxide will find a valuable place in modern industry. It is extremely difficult to give any simple formula whereby the economic advantages of CO_2 cooling can be assessed and, until wide experience has been gained, any broad generalisations are unjustified. A simple example from one of the most favourable cases is quoted by the firm on the dry turning of high tensile steel. Results showed that the use of CO_2 gave at least two-fold increase in cutting speed and doubled tool life. With a maximum power absorption in the work of 15 h.p., the amount of CO_2 needed to keep a tool tip sufficiently cool would be in the order of 7½/15 lb per hour.

Stabilised A.C. Supply for Research and Industry

For certain industrial processes and research work which require a stable power supply, Salford Electrical Instruments, Ltd., Magnet House, Kingsway, London, W.C.2, has produced an instrument to maintain stable output voltage and frequency despite considerable mains variations. It is designed to hold, at its output stage, any voltage from 200V to 250V within ±1V and any frequency from 34 to 66 cycles per second within ±0·05 cycles per second to compensate for mains variations from −10V to +20V at the input stage.

As illustrated herewith, the instrument is mounted on a standard mobile 19in rack. It consists of four sub-assemblies—an oscillator, a 100W amplifier, an amplifier power unit and a voltage stabiliser. A simplified schematic circuit diagram of the equipment is reproduced here.

The oscillator is a phase-shift oscillator based on the Wien bridge with amplitude stabilisation, using a thermistor as the feed-back resistor. The phase-shift network and the thermistor are in an oven, the temperature of which is maintained constant at 43 deg. Cent. to overcome the effects of ambient temperature variation. The h.t. voltage is stabilised by two neon tubes. The oscillator covers a frequency range from 34 to 66 cycles per second with an accuracy of better



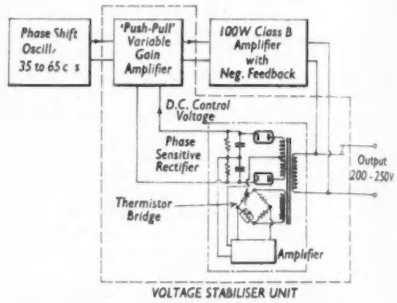
Equipment for Stabilising A.C. Mains Supplies

than 0·1 cycles per second. The frequency stability is better than 0·05 cycles per second after an initial warming up period of at least two hours. The output voltage is approximately 5V p p and the distortion is less than 0·5 per cent total.

The 100W amplifier is a class-B push-pull amplifier with four "Osram DA41" valves in parallel push-pull driven by two "Osram KT61" valves as cathode followers. The input stage is an "EF37" valve feeding an "Osram KT61" valve connected as an amplifying phase splitter. Negative feed-back is applied from the anode of the phase splitter to the cathode of the input stage to improve linearity. Negative feed-back is also applied from a separate winding on the output transformer to the input to reduce variations of gain with load. To prevent oscillation under no load conditions the gains of the input stages and the output stage are reduced at high frequencies by series *CR* circuits across the feed-back resistor and the output transformer respectively. The amplifier will give an output of 0W to 100W at any output voltage in the range 200V to 250V, r.m.s., with a total distortion of less than 5 per cent. The frequency response is flat from 30 to 100 cycles and the input voltage required is approximately 2V r.m.s.

The power unit for the 100W amplifier supplies the heater and h.t. voltages required for the amplifier unit, i.e. 7·5V, 10A; 6·3V, 2A; 6·3V, 1A; 350V, 30mA, and 1000V, 250mA.

The voltage stabiliser consists of a variable gain push-pull stage, the gain being varied by the grid bias voltage. This stage is connected in front of the 100W amplifier. The output of the 100W amplifier is fed through a suitable transformer to a non-linear bridge which balances at one voltage only. The out-of-balance voltage from the bridge is amplified and fed to the centre tap of the balanced winding on the bridge transformer, where, depending on the phase of the out-of-balance voltage, it adds to one voltage and subtracts from the other. These two voltages are then rectified and the two d.c. voltages connected in opposition. Thus, when the bridge is balanced, no d.c. voltage is obtained, but when the bridge is unbalanced either a positive or negative d.c. voltage is



Simplified Circuit Diagram of Voltage Stabiliser

obtained, depending on whether the output voltage of the 100W amplifier is too low or too high. This d.c. voltage is used to control the gain of the push-pull variable gain stage and thus to correct the amplifier input voltage. This arrangement keeps the r.m.s. value of the output voltage constant to within ±1V in the range 200V to 250V for all variations of load on the amplifier and for mains variations of −10V to +20V. A system of relays ensures that the h.t. voltage to the stabiliser is not switched on until the oven reaches its working temperature. This is indicated by a green light on the front panel.

To bring the instrument into operation all four units are switched on and it is then left for approximately forty-five minutes when a green light on the stabiliser will light up, the instrument then being ready for use. For maximum stability, however, it is necessary to allow a further one and a half to two hours.

The output voltage can be varied by the control on the stabiliser and can be checked by plugging a voltmeter into the jack socket provided. If too much load is placed on the output the stabilising action will cease and the waveform become distorted; to restore correct conditions the load must be disconnected. Similar results will occur if the mains voltage falls more than 10V below the normal voltage on loads near 100W, although on small loads large reductions in mains voltage have no effect. To avoid repetition of the warming-up period the oscillator and stabiliser can be left running continuously if required.

Chronicles of a Century.—We have received from the Ansaldo Company, of Genoa, Italy, a small booklet which has been printed in celebration of the centenary of the company. The booklet sets forth in chronological order a synopsis of some of the more important events in the history of the development of the company, including a note of its registration on January 31, 1853, and gives photographs of some of the ships built in the yards.

Reversing Reduction Epicyclic Gears for Marine Use

Some details are given below concerning two prototypes of marine reversing reduction epicyclic gears. Their design embodies the Stoeckicht principle for ensuring load sharing between planet gears and helices. Each has a reversing train with clutch and brake followed by a single reduction train, which in one unit has a fixed sun wheel and in the other a fixed spider, so that the output shafts in the ahead condition rotate in opposite directions.

SOME details have now been released by W. H. Allen, Sons and Co., Ltd., Bedford, of two prototype reversing reduction epicyclic gears for installation in twin screw vessels powered by non-reversing oil engines rotating in the same direction. The arrangement of this epicyclic gear is based on the Stoeckicht principle which ensures equal load sharing between the planet wheels and the helices. An earlier installation was described in these columns* in connection with the Allen 100kW marine gas turbine.

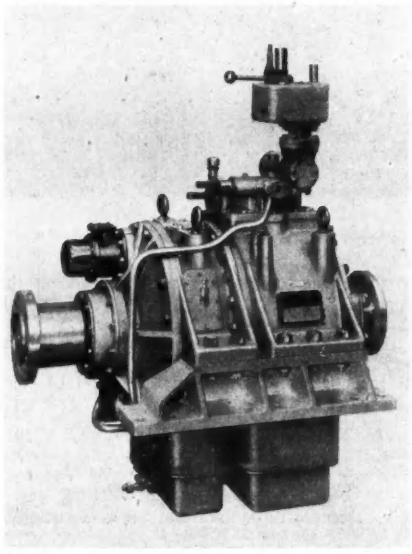
Each gear is designed on a long-life basis to transmit continuously 550 h.p. from 1000 to 625 r.p.m. when running ahead, and power according to the propeller law from 1000 to 500 r.p.m. astern.

Our illustrations have been taken from each end of one of these units and simplified sectional arrangements of the two gears are reproduced below. For the unit shown in (*b*) the input and output shafts rotate in the same direction for the ahead condition, whereas in (*a*) opposite directions of rotation of these shafts are obtained, thus giving the condition required in twin-screw vessels when unidirectional engines are employed.

Each of these gear units consists of two sections, a reversing unit and a reduction unit. The reversing unit gives a slight additional reduction when going astern. In (*b*) the second train is a solar gear (in which the sun wheel is fixed) with input and output shafts rotating in the same direction, and in (*a*) the second train is a star gear (in which the carrier is fixed) having the same ratio as the solar gear but with input and output shafts rotating in opposite directions.

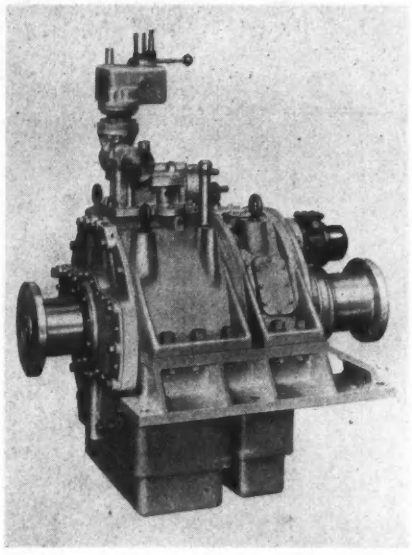
It will be seen that the reversing section for both units functions in the same way but in the case of (*b*) the input shaft is locked to the annulus of the reduction train and in the case of (*a*) it is locked to the sun wheel.

In the ahead condition the clutch of the reversing unit is engaged, locking together the sun wheel and annulus of this train so that the whole of the reversing system acts as a solid coupling between the input shaft and the reduction train. Although there is no reduction in the reversing train when running ahead, there are no idling components to cause wasted energy. For the astern condition, the clutch is released and the brake applied. This brake, which is not shown in the diagrams, holds the carrier of the reversing train so that it acts as a star gear, thus causing the moving parts of the reduction train to rotate in directions opposite to those for ahead running. Here again, there is no waste of power since all the gear components are being usefully employed.



Reversing Reduction Epicyclic Gear Seen From the Propeller End

At the engine end of the gear units an auxiliary drive is provided for two gear-type oil pumps, one of which supplies oil at a pressure of 250 lb per square inch for the hydraulically operated clutch and brake, and the other supplies oil at a pressure of 30 lb per square inch for lubrication purposes. At the propeller end of the gear units there is another auxiliary drive for an electrical tachometer transmitter and a "trailing" oil pump for supplying lubricating oil to the moving parts of the gears when the shaft is trailing.



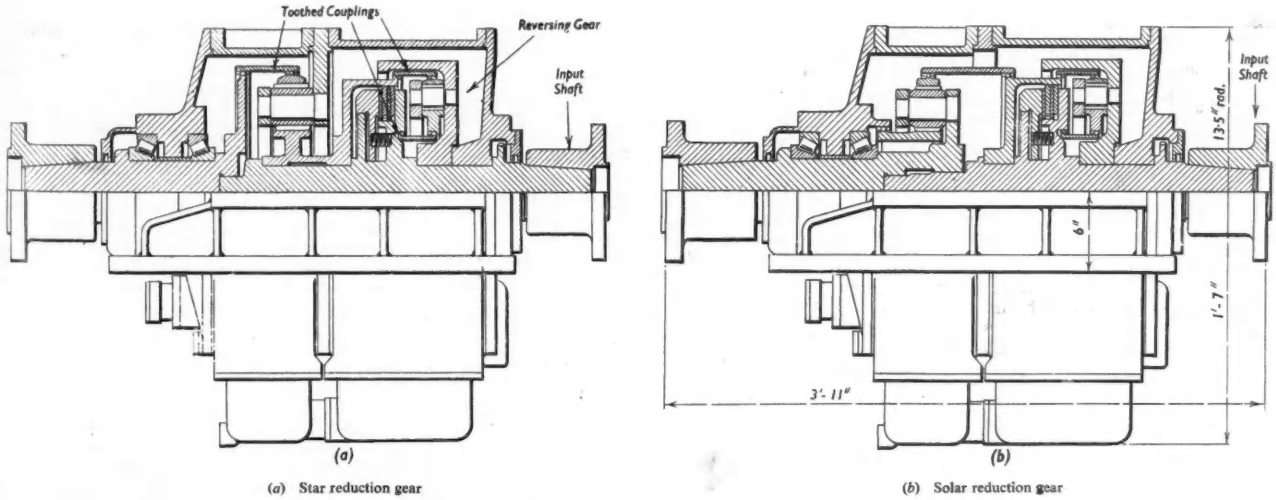
Gear Unit Seen From the Engine End

The hydraulically operated brake in each reversing unit consists of a number of brake shoes arranged around the periphery of a brake drum. At the back of these shoes there is a synthetic rubber seal and oil pressure on this seal causes the shoes to move inwards to contact the brake drum. When the oil pressure is released the shoes are returned by the action of four circlip springs. The clutch is formed by several cast iron and steel plates, oil pressure at the back of this assembly causing the plates to move together against the force exerted by a set of coil springs which are responsible for disengaging the clutch plates on release of the oil pressure.

The hydraulic control valve and engine control interlock for each gear are mounted on top of the reverse unit casing and both can be seen clearly in our illustrations. The interlock, which is the upper of the two, has been designed and constructed by the main engine makers and its function in each main engine set is to interlock the engine throttle valve with the gear reversing mechanism. This enables the speed of the engine and the direction of rotation of the propeller shafts to be determined by the movement of one lever. In the vessels for which these gears are intended there are several control positions other than the position on each gear, connection to the other controls being through control tubing.

The overall length of each gear unit is 3ft 11in,

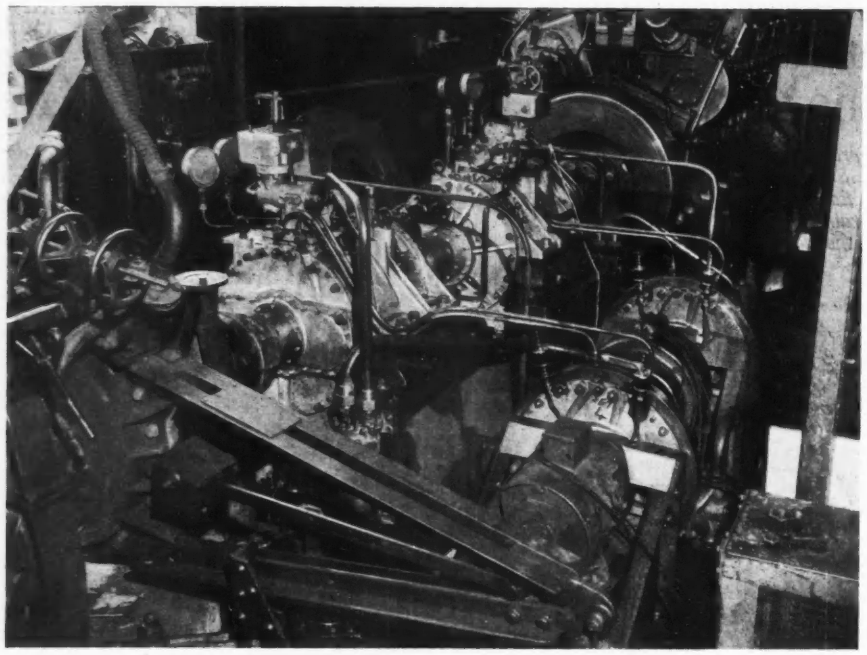
* See THE ENGINEER, November 16 and 23, 1951.



(*a*) Star reduction gear

(*b*) Solar reduction gear

Main Propulsion Reversing Reduction Epicyclic Gear



Both Gear Units Mounted in Series on Test Bed

with a centre height of 1ft 7in from the bottom of the sump and 6in from the bottom of the bearers, and an overall height of 2ft 8½in to the top of the gear case. The weight of each gear unit, excluding the steel bearers, is approximately 16 cwt.

The illustration on this page shows the test rig used at Bedford for the extensive test programme carried out on these gears, and for demonstration purposes. It will be seen that the two gears are mounted in series, that having the solar reduction gear being connected through a "Twiflex" centrifugal coupling to an Allen engine and placed as it will be when installed on board, that is, with the reversing unit next to the engine. (On board, two of these "Twiflex" couplings, connected together by a short cardan shaft, will be employed.) The gear having the Star reduction train is placed with its output coupling connected to the output coupling of the solar reduction gear, what is normally the input coupling for this gear being connected to the non-reversing dynamometer.

The engine rotates in a clockwise direction looking on the flywheel and the rotation of the shafts between the two gear units is in the same direction. Due to the star reduction gear in the second unit, the dynamometer rotates in the opposite direction to the rotation of the engine. As this dynamometer is non-reversing it is necessary for the control systems of the gears to be connected together so that the reversal of rotation in one gear unit, due to operation of its control system, automatically and instantaneously produces a similar change in the other unit. It is, therefore, possible to demonstrate the reversing characteristics of the two gears simultaneously.

The Allen engine used has a maximum speed of 800 r.p.m. as compared with the 1000 r.p.m. operating speed of the engines with which these particular gears will be associated when in service, and their direction of rotation is opposite to that of the Allen engine.

For these reasons, several modifications have had to be made to the test rig arrangement and the testing conditions. The latter have been calculated to give the same torque transmissions as are called for in service, but at the lower driving speed of 800 r.p.m. The major modification carried out to the test rig because of opposite engine rotation is that the main lubricating and control oil pumps are separately driven by electric motors instead of being gear driven in the gear units themselves, as already described. As the "trailing" oil pumps are bi-directional, they are still mounted on the gear cases and driven from the low-speed ends of the reduction gears. The control interlocks are not connected to the engine control so that the speed of the engine is adjusted at the engine and not through the interlocks as will be the case in service.

Two similar gears have already passed their acceptance tests at speeds up to 1000 r.p.m. at the engine maker's works, where they were endurance tested with the kind of engine with which they will be associated.

Festival Hall Heat Pump

By P. E. MONTAGNON, B.A., B.Sc.,* and A. L. RUCKLEY, A.F.R.Ae.S.†

This paper, presented to the Institute of Fuel on December 22, 1953, gave a detailed account of the heat pump at the Royal Festival Hall, its design, construction, costs, &c. The design of the pump was described generally in our issue of June 29, 1951, and in the following abstracts we confine ourselves to the reasons for installing the plant and its operation and costs.

TOWARDS the end of 1948 it was decided that the newly formed Chief Scientist's Division of the Ministry of Fuel and Power should undertake as one of its first tasks the development of a large heat pump, with a view to obtaining some genuine full-scale economic data for such a plant. About this time it was learnt that the Royal Festival Hall was to be heated by a hot water system based on gas-fired boilers, the choice of fuel having been partly determined by the inconvenience of solid fuel and ash handling. Preliminary assessment had shown that it was very unlikely that a heat pump could compete on an overall cost basis with a solid fuel appliance for space heating; it was only when for various reasons a more expensive fuel was chosen that the heat pump was likely to be an economic proposition. The circumstances therefore seemed suitable for comparing conventional and heat-pump space heating on a large-scale basis, particularly as the Thames would be a convenient source of unlimited quantities of low-grade heat. Arrangements were accordingly made with the effect that while no changes whatever were proposed to the planned heating system in the hall, an experimental heat pump would be built and operated in parallel with the conventional heating system so that a direct comparison could be made between the two systems.

A first consequence of this arrangement was the decision to try to use town gas as the fuel for the heat-pump prime mover, thus making direct comparison between the two heating systems even more precise. The choice of gas rather than electricity had the added attraction of offering the chance to recover as much as possible of the waste heat inevitably associated with power production in a heat engine.

It was important to decide at the outset what should be the capacity of the heat pump to make it an effective unit in relation to the Festival Hall but yet not making it so large that its full output could only be achieved in exceptionally cold conditions. It has always been recognised that a plant of the heat-pump type represents fuel saving at the expense of a large capital outlay; so that to be economic it should be a base-load plant, "topping up" in cold spells being done by a more conventional or, at least, less expensive plant. It would have been ideal if a calculation could have been made of the appropriate size for the heat pump on this basis, the "topping up" being done when necessary by the gas boilers. This was not possible for a number of reasons, not least of which was the complete absence of information on the likely number of hours per year when the hall would be occupied.

The only information available was the estimated peak load heating requirement for each of the various parts of the hall totalling some 26,000,000 B.Th.U. per hour, including an allowance of some 9,000,000 B.Th.U. per hour for the part of the hall to be built later.

To meet this load a set of boilers with a total capacity of about 30,000,000 B.Th.U. per hour was planned for the conventional heating system in the hall; and somewhat arbitrarily it was decided that an output of about 8,000,000 to 9,000,000 B.Th.U. per hour would be the appropriate level round which to design a heat pump. This choice proved in the event to be quite inappropriate, because the peak load on the hall had been seriously overestimated.

Preliminary scheming of a plant with this capacity indicated that the engine power would have to be in the neighbourhood of 700 h.p. and the mass flow of a suitable refrigerant, such as Freon, would have to be about 25 lb per second (i.e. about 25 cubic feet per second as saturated vapour at 0 deg. Cent.) It was apparent that standard gas engines running at comparatively low speeds and the normal reciprocating refrigerant compressors would be very unwieldy items to meet these requirements.

As a result the chance was taken of adding to the project the idea of using high-speed reciprocating engines and high-speed compressors of the centrifugal rather than the positive displacement type. It was intended that this should lead to indications whether such apparatus, normally only associated with aircraft practice, could be adapted for use in a wider field where long life and low maintenance costs are important. The space-saving advantages of the high-speed equipment were obvious. Another advantage of the centrifugal compressor was that it would be unaffected if the refrigerant to be compressed was not entirely in gaseous form but contained drops of liquid. A positive displacement compressor has to be specially adapted to deal with this possibility.

There was one feature of the conditions expected in the Festival Hall that was thought likely to militate against the success of the heat pump. For architectural and other reasons all heating surfaces in the hall were being kept to a minimum, with the consequence that the operating temperatures of the water system were to be very high. It was proposed to operate the boilers to heat water to 180 deg. Fah. with a return temperature of 140 deg. Fah. or above in conditions when maximum heat output was required, rather lower temperatures obtaining in less cold conditions. Such high temperatures, while being easily achieved by gas boilers, undoubtedly limited the extent to which a heat pump could be expected to be successfully exploited.

A compensating attraction for associating a heat pump with the Festival Hall was found in the fact that no equipment was being provided to cool the hall in summer-time. Although the scale of the heat pump would be determined by the heating load to be carried, the plant could with little adaptation be made to provide a supply of chilled water for cooling.

Apart from the inevitable minor faults in a plant of this kind which had to be put right one by one, there were certain inherent difficulties in

* Senior Principal Scientific Officer, Chief Scientist's Division, Ministry of Fuel and Power.
† Senior Experimental Officer, Chief Scientist's Division, Ministry of Fuel and Power.

operation which necessitated the development of special operating techniques. There were also certain failures of the components.

The chief difficulty in using the plant was one which was never overcome, namely that events proved that the maximum load required by the concert hall was vastly below the estimate which had been provided at the start; 8,000,000 to 9,000,000 B.Th.U. per hour output from the heat pump overwhelmed the requirement by several million B.Th.U. per hour, with the effect that a steady load for the plant was never achieved and all records had to be taken during a rising temperature régime. More important, long runs of the plant could not be managed.

There were two major failures of the plant during the operating period. The first of these was the failure of the centrifugal clutches in the gearbox driving the first-stage compressor. Subsequent analysis showed that high torque at low speed was a possible condition during starting. The clutches were replaced, stronger retaining springs were installed and the trouble did not recur.

The second major disaster was the complete stripping of the first-stage impeller after some fifty running hours. Inspection of the damage led to the conclusion that one of the rotating guide vanes had failed when the plant was on load and all the remaining damage was consequential on this. This trouble was traced to the unfortunate fact that a resonant frequency of the vanes was very near a typical operating speed. The trouble was overcome by fitting a shroud round the rotating guide vanes, thus increasing stiffness substantially.

The only other failure worth recording was that the rotating seal on the second-stage compressor retracted under certain conditions of high interstage pressure, with the consequent loss of refrigerant. It proved possible to overcome this difficulty by fitting a stronger retaining spring to the seal.

Other faults were comparatively minor ones and were dealt with as they arose. The engines themselves operated satisfactorily throughout.

The cost of the whole project was, of course, much in excess of what might be expected for a duplicate of the installation. The total cost was roughly £103,200.

It would obviously be unfair to base comparisons between this and other methods of heating; but analysis of the figures suggests what might be taken as reasonable for a second installation of the same type. The suggested figures might be roughly as follows :—

	£
Main heat exchangers, refrigerating equipment, &c. (main saving from use of smaller heat exchanger tubes and manual control of refrigerant throttling)	10,000
Production of engine and compressor units ... ... (main saving by absence of development costs)	17,500
Installation of plant, pipework, builders' work, &c. (main saving by more suitable siting of plant room)	20,000
Sundry payments	5,000
Total	£52,500
Cost per therm/hr installed ...	£575/therm/hr.

The annual charge on this sum is difficult to assess, because there is such a wide variation of the " life " between one component and another. A suggested division would be :—

Engine and compressor units	7-year life
Refrigerating equipment (including heat exchangers)	15-year life
Remainder	30-year life

On this basis, and allowing 4 per cent interest, the annual charge works out at exactly 10 per cent of the capital sum, i.e. £5250 per annum or £575 per annum per therm per hour installed per hour.

To these annual charges additions must be made to cover maintenance and attendance. Only seven years having been allowed for the complete replacement of the mechanical parts of the plant, an additional £150 per annum should be sufficient to cover maintenance, which would be mainly on annual overhaul of engines and sealing mechanism. (It should be mentioned here that during the whole of the running period, which now amounts to several hundreds of hours, no fault developed in the mechanical part of the plant which was not put right by routine inspection or that was not due to design features which were modified.)

Attendance would either have to be continuous during operating hours or, alternatively, substantial costs would have to be incurred for automatic control. This position would be relieved if the plant were a genuine base-load plant and did not have to follow continuous fluctuations in load. An allowance of £1000 per annum for almost continuous attendance is suggested.

Thus the total annual charges become £6400.

Inspection of the results shows that waste heat collection was not nearly as effective as it might have been. This was the inevitable result of attention having been paid almost entirely to the heat-pump part of the plant. Analysis of the results suggests that an overall efficiency of about 1·25 might be achieved consistently with the water temperatures involved. (The highest recorded result was 1·42.) A higher figure would, of course, be possible with a lower temperature heating system, but this in turn would involve more extensive heating surfaces inside the building. (This figure of 1·25 for overall efficiency must not be confused with the more usual coefficient of performance of heat pumps which is based on heat output compared with power input (not fuel input).

On this basis the fuel cost per therm provided works out at 10·6d. per therm, allowing for both gas burnt and electricity consumed for pumping, &c.

Comparison of these figures with the actual cost of heating the Festival Hall by conventional gas-fired boilers is not reasonable because of the discrepancy between the size of the boiler installation and the heat requirement. A gas boiler installation of the same output as the heat pump might be expected to incur annual charges of about £750 and a fuel cost of about 17·4d. per therm on full load.

Direct comparison of these two sets of figures indicates that a load factor of at least 25 per cent must be achieved for the heat pump to show a financial saving. In practice the figure would be higher than this because, although both types of plant fall off substantially in efficiency when running on part load, the heat pump with centrifugal compressor falls off much faster in efficiency than a conventional boiler. The effect can be partially overcome by dividing the plant into separate units, but this would increase the cost and complexity of the plant. A much more satisfactory solution would be to make the heat pump a base-load plant with a consequent improvement in load factor (as was originally intended). An element of thermal storage introduced into the system would further help in showing the heat pump to advantage.

A very different picture appears in those situations where (as with the Festival Hall) some summer cooling is a desirable feature. The heat pump will do duty as a refrigerator, and so the capital cost of a refrigerator can be offset against the cost of the heat pump. It was found that the heat pump as installed was a little oversize (when only using one compressor) for the purpose of cooling the hall in summer. As a heating unit (using two compressors) it was too large even for the peak load on the hall.

An installation designed round the refrigerating requirements might therefore be supposed to be a reasonable base-load plant for heating requirements. In such a case nearly all the fuel saving derived from the heat pump could count as genuine financial gain.

Rolling Stock for Manchester-Glossop Electric Services

We learn from the London Midland Region of British Railways that successful preliminary trial runs took place recently with the first units of multiple-unit stock for the Manchester (London Road)-Glossop electric services for the next stage of the Manchester-Sheffield-Wath electrification, which is due to come into operation in mid-1954. Both sides of the triangular junction of the Glossop branch with the main line have been electrified and the trial runs have been made between Godley Junction and Glossop both direct and via Hadfield, with trains composed of one and two three-coach units. For the Manchester-Glossop route eight three-car trains, each consisting of a motor coach, trailer and driving trailer, are being provided. The electrical equipment was supplied by The General Electric Company, Ltd., and the vehicles were built by the Metropolitan-Cammell Carriage and Wagon Company, Ltd.

Each motor coach is powered by four G.E.C. axle-hung, nose-suspended, self-ventilated traction motors with one-hour ratings of 185 h.p. on full field and 210 h.p. on weak field. The system voltage is 1500V d.c., and the motors are connected in series pairs, with control by series or parallel connection of the two pairs in a motor coach. The electro-pneumatic contactor control equipment is underframe-mounted, and the whole of the electrical equipment has been designed for satisfactory operation over the fairly wide range of line voltage that may be encountered on this route, where regenerative braking will be used by electric locomotives working heavy goods trains over the lengthy gradients on the main line.

The motor coaches each seat fifty-two third-class passengers, the trailers twenty-four first and thirty-eight third, and the driving trailers sixty third. Thus the three-car trains will accommodate 174 seated passengers and the six-car trains twice that number. The coach bodies are of all-steel construction, each coach being fitted with two pairs of electro-pneumatically operated sliding doors with permissive passenger control.

The interiors are lined with birch and sycamore veneered plywood, in natural white wood finish, the ceilings and spandrels being painted cream. The large windows are framed in dark teak. The seats are covered in moquette, blue in the smoking sections and russet elsewhere. Metal screens by the doorways are fitted with ⅜in armour plate glass panels. Heating is effected by 400W heaters mounted beneath the seats.

Battery-Operated Mobile Cranes

Two battery-operated, self-propelled, 1-ton capacity mobile cranes have been designed and built by Steels Engineering Products, Ltd., of Sunderland, for a factory engaged in the manufacture of heavy duty bushings and other equipment for the electrical industry. These " Coles " cranes are fitted with 15ft cantilever jibs and they can travel with loads ranging from 7½ cwt at the maximum radius of 15ft to 1 ton at 8ft.

Each crane motion—hoisting, derricking, slewing and travelling—is operated by a separate electric motor. These motors, with the exception of the travel motor, are mounted on the four-wheeled chassis and housed in the fully enclosed revolving superstructure, together with the battery and control gear.

The hoisting motion is driven by a 1¾ h.p. vertically-mounted motor through a worm reduction gear, and lifts the maximum load of 1 ton at a speed of 35ft per minute. The derricking gear which raises or lowers the jib is of similar construction. A third 1¾ h.p. motor slews the superstructure in a complete circle in either direction and its drive is transmitted by a vertical worm reduction gear through a propeller shaft and a special slipping clutch which prevents the transmission of shocks on starting and stopping. The superstructure revolves on a large diameter live ring of steel rollers running on top and bottom paths of steel, thus ensuring that loads are evenly distributed over the welded steel chassis frame.

The 80V, 6 h.p. travelling motor is connected by a propeller shaft to a differential with a reversible worm and wheel on the fully floating rear axle. The crane has a maximum road speed of 4 to 5 m.p.h. unloaded and 3 to 4 m.p.h. loaded.

The battery, forty " Exide-Ironclad " cells with a capacity of 192Ah, is arranged in two 40V sections. These two halves are connected in parallel for the hoist, derrick and slew motors and for the first and second travel speed positions. For third and fourth travel positions the batteries are connected in series to provide 80V, enabling the travel motor to develop full power.

The hoist, derrick and slew motors are wired through the travel controller which disconnects the supply to these motors when third or fourth travel speeds are in use. With an overall length in travelling order of 19ft 6in and a track of 4ft 6in, each crane has a clearance height of 8ft 9in with the jib horizontal and a chassis turning circle of 20ft. The approximate unladen weight is 5 tons.

A.C. Slant Haulage Drive with Dynamic Braking

An alternating-current slant haulage drive, which is believed to be the largest equipped with dynamic braking in South Wales, has recently been commissioned by the National Coal Board at Pantyffynnon Colliery, near Ammanford. Until the new drive was installed the Pantyffynnon haulage was driven by a steam reciprocating engine. In the new installation the winder drum of the original haulage has been retained, but it is now driven through reduction gearing by a reversible a.c. slipring motor with an r.m.s. rating of 700 h.p. The electrical plant and control gear, as described here, for the new drive was supplied by The General Electric Company, Ltd.

The total length of the Pantyffynnon haulage is 1000 yards over gradients ranging from 1 : 2·1 to 1 : 5·5, and the maximum load is eleven trams with a total deadweight of 17 tons. The normal duty cycle provides for seven journeys per hour at a maximum rope speed of 12½ m.p.h., representing a total of 475 tons of coal raised per eight-hour shift. When used for man riding the maximum rope speed is limited to 6¼ m.p.h.

Electrical Plant and Control Gear

The electrical plant consists of the main haulage motor, a motor generator set which provides the d.c. supply for dynamic braking, and two 220V motors which drive the assister gear and electrolyte pumps for the liquid controller.

The main switchgear consists of a two-cubicle 3·3kV switchboard fitted with an oil circuit breaker of 75MVA rating for controlling the supply to the winder motor ; and h.r.c. fuses for controlling the supply to the 40kVA auxiliary transformer. The 220V secondary of this transformer feeds a fused low-voltage distribution board. The control gear for the winder motor consists of a stator reverser and a weir liquid controller with a continuous dissipation of 250 h.p. The motor driving the m.g. set is provided with a star-delta starter, but the other auxiliary drives are equipped with direct-to-line contactor starters.

The main haulage motor is a 3·3kV reversible, screen-protected slipring machine rated at 700 h.p. at 365 r.p.m., and is fitted with two pedestal journal bearings. The three-machine m.g. set for dynamic braking comprises a 32 h.p., 220V induction motor direct coupled to a pilot exciter and to a main exciter with an output of 20kW.

The 3·3kV switchboard is fitted with independent air-break isolators for the haulage motor and the auxiliary transformer. The stator reverser is an air-break equipment with sections for forward and reverse winding and dynamic braking. It is electrically operated and is fitted with interlocks to prevent the simultaneous closing of the forward and reverse or dynamic braking contactors, and to ensure that the arc is completely cleared before the next switching operation is carried out.

In the liquid controller (Fig. 1) the moving electrodes form a weir to retain or release the electrolyte in the three insulated electrode chambers. Electrolyte is pumped from a lower compartment into a common header which feeds the electrode chambers. An oil-operated servo unit is used to operate the liquid controller, and to determine the rate of acceleration of the electrode movement, and consequently of the haulage motor.

The servo unit consists of a fixed piston with a moving cylinder which carries a toothed rack. This rack engages with a quadrant to which is connected a lever which in turn operates the controller. The unit controls the rate of acceleration and co-ordinates rotor resistance with excitation during dynamic braking. When starting, it is only necessary for the driver to move the control lever to the full-on position, while the servo unit automatically takes care of the rate at which the rotor resistance is cut out.

The cam-operated master controller is mounted in the control desk shown in the foreground of Fig. 2. Discriminating back-out switches are incorporated which can be operated by means of a knob mounted on the top of the control unit. An emergency stop push button and a man/coal switch for setting the appropriate overspeed tripping are also mounted in the top of this desk. The auxiliary control gear for the stator reverser and the dynamic braking system is housed in a cubicle of sheet steel construction.

The driver's control lever operates in an H-gate ; when it is in the neutral position movement to the left energises the appropriate contacts in the master controller for forward winding and dynamic braking. By moving the lever forward from the neutral position the appropriate a.c. stator contactors are closed and the winder motor accelerates at a rate determined by the servo mechanism of the liquid controller, to a speed which is fixed by the position of the control lever. Movement of the control lever backwards from the neutral position disconnects the stator of the haulage motor from the 3·3kV supply and connects one phase of the stator winding to the d.c. supply from the dynamic braking m.g. set. The degree of braking is then controlled by the position of the control lever, which is mechanically coupled to the dynamic braking regulator.

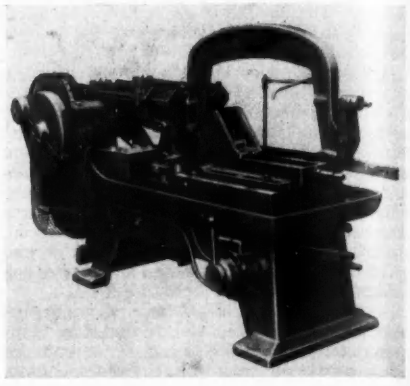
Similarly, when the control lever is in the neutral position and is moved to the right, the master controller contacts for reverse winding and dynamic braking are energised and a backward movement of the control lever causes the motor to accelerate in the reverse direction, while a forward movement applies the dynamic braking.

Overspeed tripping is related to the coal and man limits by a two-range relay which operates in conjunction with a tacho-generator mechanically coupled to the haulage motor. Operation of the man/coal switch on the driver's control desk automatically selects the appropriate relay range of 6¼ m.p.h. maximum for men or 12½ m.p.h. maximum for coal. Different decking levels are used for man riding and coal hauling, and the overwind limit switches which are fitted in each of these positions are also correctly related by the man/coal switch on the control desk.

Heavy-Duty Hacksawing Machine

The heavy-duty hacksawing machines of 10in and 12in capacity made by Edward G. Herbert, Ltd., Atlas Works, Levenshulme, Manchester, 19, are now being fitted with a hydraulic support for the frame. The machines have a hydraulic pump unit which raises the saw frame at the end of the cut, and also holds the saw frame at any convenient height above the work when inserting bars or sections smaller than the full capacity of the machine.

The new mechanism fitted to the hacksawing machine illustrated below, consists of a two-throw plunger pump operated by two eccentrics on the main shaft, a lever-operated control valve, an oil reservoir and a new valve release incorporated in the dashpot piston. The arrangement does not interfere with the action of the automatic lift to the saw blade on the return stroke, but adjustment of the feed automatically controls the amount of this lift. Whilst the main shaft of the machine is turning oil is pumped under pressure from the reservoir to the control valve, and according to the position of this valve the oil is either circulated back to the reservoir or fed into the dashpot cylinder below the piston, which is then forced upwards to lift the saw frame. When the frame reaches the maximum height, movement is stopped automatically by the action of a relief valve on the dashpot piston.



Hacksawing Machine with Hydraulic Frame Support Unit

When the control lever of the machine is placed in the " feed " position, the oil flows back to the reservoir, releasing the pressure on the dashpot piston to lower the saw on to the work. There is also a " dwell " position for the control lever, and when it is in this position sufficient oil is pumped into the dashpot to hold the saw frame at any convenient height, short of the maximum, while the operator fixes the work in the vice.

The new equipment, we are informed, can be fitted without difficulty to existing machines arranged for the standard single or multi-speed motor drive.

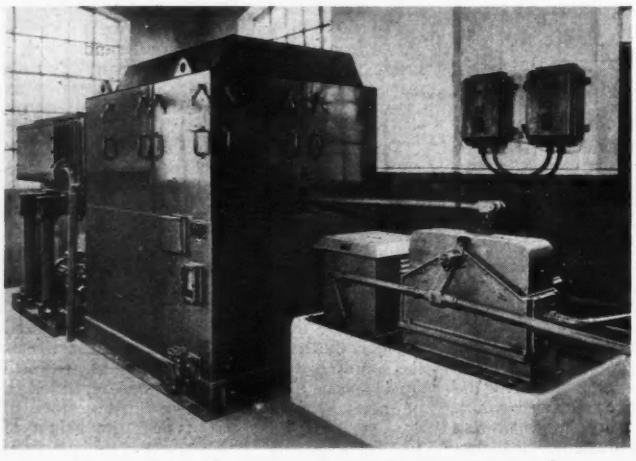


Fig. 1—Liquid Controller and Assister Gear for 700 h.p. Haulage Motor

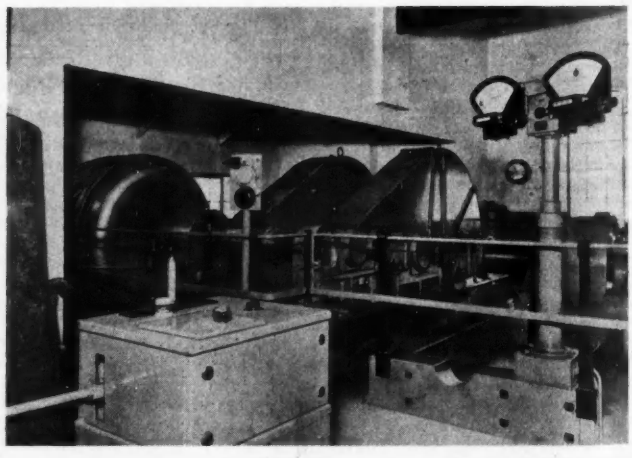
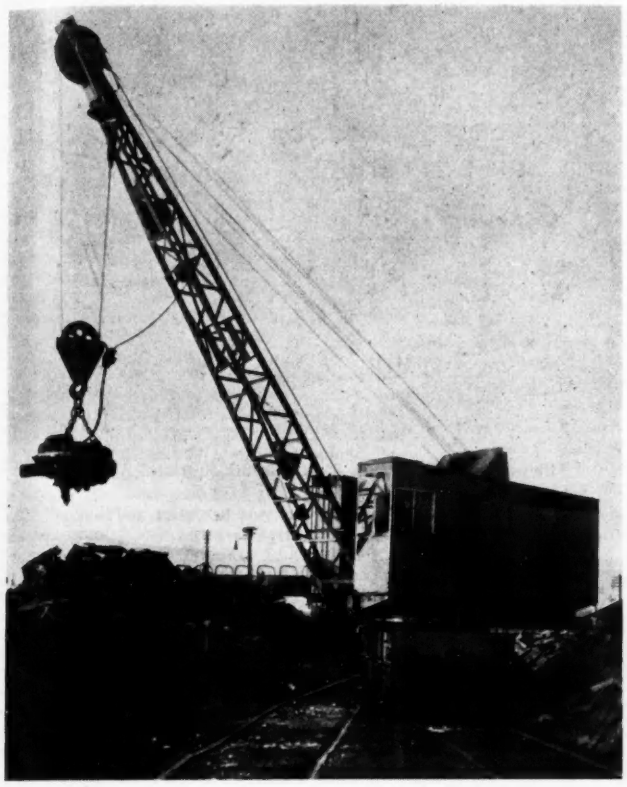


Fig. 2—Winder House, Driver's Control and Indicator at Pantyffynnon Colliery

10-Ton Self-Propelled Crane

THE photograph we reproduce on this page shows a 10-ton diesel-electric, double-bogie rail crane which has recently been delivered to Colvilles, Ltd., Glasgow, to operate on general crane duties in the steel works at Glengarnock. The crane was built by Thomas Smith and Sons (Rodley), Ltd., of Rodley, Leeds, and was specially constructed to withstand arduous steel-works duties. It has a 120 h.p. diesel generator set situated at the rear of the superstructure, which supplies electric current to the crane motors, electro-magnet and floodlighting, and makes the machine independent of external power supplies.



10-ton Crane in Operation with an Electro-Magnet

The crane weighs 70 tons and is of all-welded construction with a fully revolving superstructure. When fitted with a 35ft jib the crane is capable of handling the following working loads, free on rails :—10 tons at 20ft radius at 60ft per minute ; 5 tons at 30ft radius at 120ft per minute, and 4 tons at 35ft radius ; when used for grabbing its capacity is 4 tons at 30ft radius at 120ft per minute, or 3¼ tons at 35ft radius. Facilities for operating a 55in diameter Igranic magnet are also incorporated. The crane has a slewing speed of 1 revolution in thirty seconds with a 10-ton load, whilst it can travel with a full load at 200ft per minute. Curves of 130ft radius can be negotiated and the crane can be used for hauling 90-ton loads at about 150ft per minute ; it can also travel, unloaded, up 1 in 30 gradients.

The jib is an all-welded, double-latticed structure, 35ft long, and provision is made for the fitting of a longer jib if required. A Vickers Nash safe load indicator has visible and audible warning devices near the driver's position. A wide cast steel hoist pulley to accommodate a bordeaux connection for grabbing is mounted at the jib head, and provision is made for ring discharge suspension. To prevent the grab spinning, a specially-designed unit with a sliding weight has been fitted at the front of the cab on the side remote from the driver. Also incorporated in the jib assembly are a spring-loaded cable drum for the magnet and a balanced floodlight. To facilitate interchangeability and maintenance, all the crane motions are driven by standard motors of the " Metrovick " mill type, which are normally stocked by the users.

The carriage, of fabricated steel construction, is fitted with buffers and drawgear at each end, and provision is made on its frame for accommodating a large amount of cast iron ballast. The carriage structure is supported on two fabricated steel, four-wheeled bogies, each bogie being fitted with an electric motor of 25 b.h.p. at 575 r.p.m. and driving directly through a spur gear reduction, totally enclosed in an oil-tight gearbox. The axle spur pinion and wheel is enclosed in a special gear case to allow for vertical springing and lateral axle movement. Draw beams and screw jacks are fitted in each bogie. Special attention has been paid to facilitating the maintenance of the bogies and providing means of easy access to the machinery, and the centre pins can be easily removed so that the bogies can be withdrawn completely from the carriage. The fabricated revolving superstructure rotates round a kingpost arranged centrally between the two bogies and it is supported on a live ring of bushed rollers coupled to the centre post by a nave ring and radial rods.

The power supply unit consists of a six-cylinder, water-cooled Leyland diesel engine, developing 120 b.h.p. at about 1600 r.p.m., coupled through a " Layrub " flexible coupling to a continuously rated generator, supplied by Lancashire Dynamo and Crypto, Ltd., and giving an output of 75kW at 230V d.c. The complete power unit, with the exception of the generator commutator end, is fully enclosed in removable metal cowlings.

Power for hoisting is supplied through a 60 h.p. motor which is directly coupled through spur reduction gearing to the hoist barrel shaft. The barrel has machine-cut rope grooves, and is capable of handling 170ft of rope. Dynamic braking with potentiometer controlled lowering is provided and an electro-magnetic brake is situated on the motor extension shaft.

Slewing is effected by a 7½ b.h.p. motor driving through a high-tensile steel worm and phosphor-bronze worm wheel rim, totally enclosed in an oil-tight box. An adjustable spring-loaded friction clutch is incorporated to take up any additional forces which may be set up by sudden stopping of the slewing gear by braking or other means.

The derricking motion machinery situated to the rear of the superstructure consists of a 20 b.h.p. motor directly coupled to a worm reduction unit driving a pinion and spur wheel rim, bolted to the derrick drum. The derrick rope passes from the drum over intermediate pulleys situated at the apex of the " A " frame and thence to the derrick pulleys at the jib head. To eliminate the possibility of the jib moving out on its own accord an automatic thrust brake is incorporated in the worm box unit. This brake consists of a ratchet and friction plate clutch so adjusted as to operate only against the load; lowering of the jib must therefore be assisted by the derrick motor.

The hoisting, slewing, derricking and travelling controllers operated from the driving position at the front end of the cab are simple to operate and arranged so as to reduce driving fatigue to a minimum. The Igranic hoisting control has an enclosed contactor panel, and provides series resistance control in the hoisting direction with dynamic braking and potentiometer controlled lowering. The cam-operated hoist master controller is fitted with standard operating handle with a central off position and five notches in each direction. Slewing and derricking controllers of the standard drum pattern have off position interlocks and cranked operating handles giving seven notches forward and reverse.

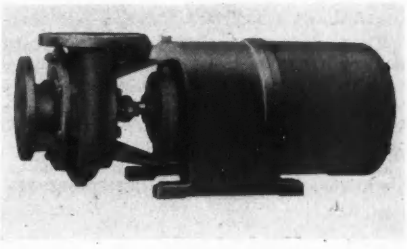
The travelling motors are controlled by an Igranic master controller and contactor panel consisting of plain series control, two plugging and three accelerating contactors giving graduated torque in conjunction with set time relays situated in the contactor panel. The lifting magnet control equipment consists of a totally enclosed housing incorporating the contactor gear together with discharge and reverse current resistances, &c. The main current supply to all motors and magnet is controlled from a central panel situated on the revolving superstructure. This panel, which supplies overload protection for all the motors, is energised by a start and stop press-button control near the driver's position.

The superstructure machinery and engine is fully enclosed in a steel cab with removable side panels to allow easy access to the power unit and electrical equipment. The cab is so arranged that the driving position is forward of the jib foot pin, and windows on three sides of the cab give the driver an unobstructed vision of all operations within a wide radius.

Motor Pump Unit

A RECENT addition to the centrifugal pumps made by Sigmund Pumps, Ltd., Team Valley, Gateshead, 11, is a range of pumping sets fitted with motors from 1½ h.p. to 15 h.p. and having capacities up to 500 gallons a minute and suitable for heads up to 175ft. These " Pum Pak " sets, as they are known, have the pump impeller mounted directly on an extension of the motor rotor shaft.

The volute pump casing, as can be seen in the illustration below, is bolted on to an extension of the cast iron main frame of the unit, and it can be arranged to give any of eight different positions for the discharge branch. The casing, suction cover, and impeller can be made in cast iron, stainless steel or bronze, according to the duty for which a pump is required. A deep section stuffing-box is arranged for a mechanical seal or for water or grease sealing, and a bronze sleeve is fitted on the shaft where it passes through the box. A moulded rubber water thrower prevents the passage of liquid into the ball bearings on which the shaft is carried in the main frame.



Motor Pump Unit

The rotor is built up of steel laminations with a centrifugally cast aluminium squirrel cage and fan fins are formed on the end rings to ventilate the motor. This fan is situated near the stuffing-box and induces a flow of air through grilles at the opposite end of the housing. Part of the flow of air cooling the pump end bearing is directed along the shaft to assist the action of the water thrower and prevent liquid entering the bearing housing. The stator is mounted as a complete unit in a housing which is attached to the main frame by four long studs. By removing four holding nuts the complete stator unit can be withdrawn for repair, inspection or maintenance. In the event of a breakdown a spare stator can be fitted to keep the pump in service whilst repairs are effected.

Smaller R.N. Fighting Craft

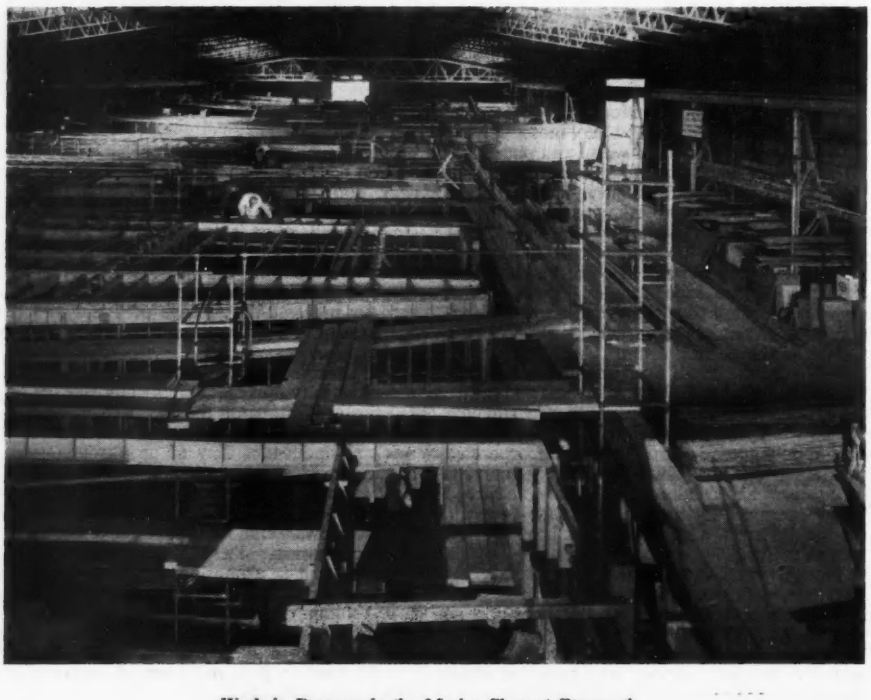
It has been pointed out to us that a paragraph immediately under the subsidiary heading "Smaller Fighting Craft" on page 32 of our issue of January 1st, within the article entitled "Naval Construction in 1953," is misleading in certain important respects and contains certain inaccuracies. We hasten, therefore, to publish the correct facts hereunder.

The parent firm for the design and construction of fast patrol boats of the "Dark" class for the Admiralty is Saunders-Roe (Anglesey), Ltd. These craft are of composite construction combining the advantages of considerable strength given by metal framing with high impact resistance afforded by a timber skin. They are similar in type only from the point of view of dimensions to the all-wood "Gay" class. The main machinery consists of Napier diesel engines. They are interchangeable as motor torpedo-boats and motor gunboats. Five of these craft are now being constructed at the shipyard of Saunders-Roe (Anglesey), Ltd., at Beaumaris, while the remainder are being built by the daughter firms: Vospers, Ltd.; John I. Thornycroft and Co., Ltd., at its Hampton Launch Works; James Taylor (Chertsey), Ltd.; James McGruer and Co., Ltd.; James Miller and Sons, Ltd.; and Morgan Giles, Ltd. Saunders-Roe (Anglesey), Ltd., as the parent firm, is responsible for the supply of the necessary working drawings and for providing general advice and assistance to the daughter firms. That firm is also supplying several of the daughter firms with fabricated structural components and all of them with certain components such as fuel tanks, &c. It also has contracts with the Admiralty for the design and construction of a large number of 21in light alloy torpedo tubes, some of which will be used on these fast patrol boats, and for pumping sets and hand steering gear which are also for use on these craft. Amongst other work for the Admiralty the company has under construction three wooden inshore minesweepers of the "Ham" class, and four of composite construction, with light alloy framework, of the "Ley" class.

Some of the above craft under construction are shown in the accompanying illustration of work in progress in the main marine shop at Beaumaris.

Torpedo Tubes

The torpedo tubes referred to above have been designed for fitment to the decks of small craft, such as motor torpedo boats. They are constructed in aluminium alloy throughout, and a considerable weight saving is achieved as compared with previous designs in steel. This is important in that the weight is reduced at a position where it has a pronounced effect on the stability of the boat. The tube is constructed from four lengths, two of 6ft and two of 4ft, which are provided with end flanges. The lengths are joined together by bolting through these flanges. In making a section, 8 S.W.G. (0·160in) sheet is rolled to the required diameter, and the longitudinal joint is made by mechanical "Argon Arc" welding on a specially designed rig. The flanges, which are themselves rolled from extruded bar, are then welded to the tube ends, the circumferential welding also being a mechanical operation. The various fittings required to be attached to the tube are produced as castings with flanges for riveting through the tube wall. Provision is also made for access to the various fittings in the torpedo such as stop and charging valves and depth setting adjustments. There are also attachments for pressure and velocity recorders. The rear door is cast with integral handles, and is clamped to the rear flange of the tube section. For mounting the tubes to the deck girders, cast feet are riveted to the tube at convenient positions. The tubes are "loose fitting." The torpedo is held in a special rubber ring bolted between the flanges of two of the sections. Near the rear door, tail guides are fitted to prevent rotation of the torpedo and to align the tail end correctly. Despite their light weight, the torpedo tubes as designed are said to be robust, and fully capable of withstanding the normal conditions of Service handling. All the materials used are corrosion resistant.

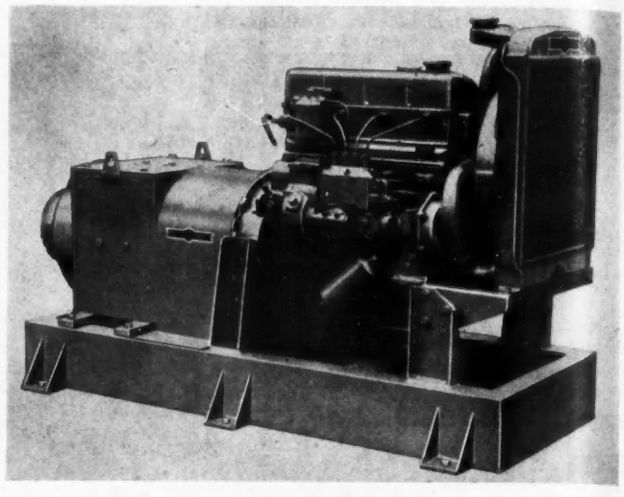


Work in Progress in the Marine Shop at Beaumaris

25kVA Diesel-Electric Generating Plant

An industrial electric generating plant recently introduced by A. C. Morrison (Engineers), Ltd., Cliff Works, Burton-on-the-Wolds, Loughborough, is illustrated on this page. The plant is of 25kVA capacity, a.c., 3-phase, 50 c/s at any standard voltage, and it was developed in co-operation with the Ford Motor Company, Ltd.

The power unit of the plant is the industrial version of a Fordson Major diesel tractor engine which has been modified and fitted with a sensitive centrifugal governor for the particular duty. This four-cylinder engine develops 34 b.h.p., and is stated to have a fuel consumption of about 1½ gallons per hour at full load. The engine is directly connected by a flexible coupling to the alternator and the assembly is mounted on a common fabricated bedplate.



Diesel-Electric Generating Plant with Self-Regulated Alternator

The standard plant (illustrated) is fitted with the recently developed Brush "Square Path," self-excited, self-regulated alternator. This alternator is a rotating armature machine, with screen-protected enclosure, and fitted with large ball and roller bearings. It has class A insulation to tropical standards. The makers state that the design is such that the inherent voltage regulation is plus or minus 5 per cent over the range of power factors from 0·8 to unity, but for any fixed power factor the regulation is improved to plus or minus 2½ per cent. The standard plant is said to be suitable for all industrial and commercial applications, but if requested it can be supplied with a Crompton Parkinson "Magnicon" self-regulating alternator or any conventional externally regulated alternator.

A push-button-operated 12V starter motor is fitted and its heavy-duty battery is charged by a 12V dynamo fitted to the engine. The control panel has three ammeters, a voltmeter and phase selector switch, a hand field regulator, and a suitably rated ironclad switch fuse. An engine control panel incorporates a starter button, battery charging ammeter, oil pressure gauge and water temperature gauge.

According to the duties for which a plant is required, it can be supplied as illustrated with a fabricated steel base for bolting down or with a skid-design base.

Automatic Pulveriser.—We have received from International Combustion, Ltd., a copy of a booklet dealing with the Raymond automatic pulveriser and lime conditioner, together with a pamphlet on the Raymond screen pulveriser. Two sizes of the conditioner are briefly discussed, together with cutaway views of the plant and a page is devoted to commercial performance data with regard to dyes, hydrated lime, synthetic resins, chemicals, sodiums and caustic materials. Similarly the pamphlet includes notes upon the operation, design and construction of the screen pulveriser and also reports taken from operating records of various plants.

Naval Divers in the Thames.—The Admiralty has stated that a team of Royal Naval divers will be working in the Thames during the next few months. They will be gaining experience of diving conditions such as are to be found in commercial ports and rivers, where water is often murky and tidal and other difficulties are to be encountered. Below the Pool of London the divers will work directly from H.M. ships "Annet" and "Flatholm." Above Tower Bridge and as far up as Battersea the team will operate from specially fitted motor cutters. The divers will wear light self-contained suits, each diver carrying his own air supply with him and being thus independent of air hose or air pump in attendant craft.

Industrial and Labour Notes

European Productivity Agency's Programme

In May of last year, the European Productivity Agency was established by the Organisation for European Economic Co-operation. At the end of last week, the Agency's first annual programme was published, the work which it is proposed to undertake being classified under the six main headings of specific economic and legal problems; technical and administrative problems of industry and commerce; human factors of management and labour; applied research and technology; food and agriculture, and information and general services.

In putting forward this programme, the O.E.E.C. defines productivity as "getting the best results out of any of the numerous factors of production, such as capital, raw materials, plant and machinery, land and labour." The final purpose of the productivity campaign, it is stated, is to secure a higher European standard of living by achieving a higher flow of goods and services "with a correspondingly higher real purchasing power in the hands of the consumer." The programme points out that the problems presented by a campaign to increase productivity are both technical and psychological, it being necessary not only to discover and make known the means whereby productivity can be increased, but also "to persuade those concerned to adopt those means." The latter, the O.E.E.C. says, is perhaps the more difficult and the more important side of the problem.

The European Productivity Agency will operate within the general framework of the O.E.E.C. and in conjunction with O.E.E.C. technical committees and other bodies. It will assist National Productivity Centres in the O.E.E.C.'s eighteen member countries in their campaigns concerned with industry, commerce and agriculture. These productivity centres and the Agency between them have at their disposal an amount equivalent to about 117 million dollars, which is made available under the American Economic Co-operation Act and from other sources. The programme says that though these resources will last only a few years, it is hoped that by the time they are exhausted the Agency will have gained a sufficient measure of confidence from management and labour in Europe, as well as from the National Productivity Centres, to ensure the support of governments for its continued existence. The Agency intends to carry out its programme by collating existing knowledge and acquiring fresh knowledge, by disseminating or exchanging that knowledge, and by stimulating the necessary action to put it into effect. This, it is stated, will involve, among many other activities, the organisation of working parties and missions, the publication of reports and digests, the organisation of training courses, the use of audio-visual aids, and the exchange of workers, specialists and trainers. The Agency's proposals for "stimulating action" include making recommendations to governments, consultations with national and international groups, and sponsoring private associations which are working towards the common goal of productivity.

Engineering Wages

The court of inquiry, under the chairmanship of Lord Justice Morris, which is investigating the wages dispute in the engineering and shipbuilding industries, ended its public sittings on Thursday of last week. On that day, Mr. Jack Tanner, representing the Confederation of Shipbuilding and Engineering Unions, made a further statement to the court. Mr. Tanner asserted that, short of a world recession, there was no need to worry unduly about the export prospects for British engineering products. He argued that the cost of the 15 per cent wage increase which the unions were claiming would be about £75,000,000 a year, and the increase on wage rates only would add much less than 3·17 per cent to the engineering industry's total costs.

Sir Percy Mills, who spoke on behalf of the Engineering and Allied Employers National Federation, said that the drop in export business was a danger to all who were concerned in this country's ability to pay its way. Against that dominant factor there could be no virtue, but great danger, in adding to individual pay packets at the present time. Sir Percy went on to say that if wage increases, on the basis of the claim, were to be applied to all the 3,727,000 workers in the engineering and allied industries, the annual cost in wage increases alone would be in the region of £171,000,000. Sir Percy also made reference to the drop in export orders and to the fact that home orders were showing a tendency to decline. Current production, he said, was generally much in excess of incoming orders and, even without an addition to wages, it seemed that the engineering industry must face higher costs in the future.

Railway Wages

At the end of last week the British Transport Commission stated that it had made an offer to the three railway unions of an advance of 6 per cent on the standard rates of pay which were in force prior to the acceptance, in December, of a tribunal's award of 4s. a week. This offer, it is understood, means increases for employees of British Railways varying from 7s. to 10s. a week, including the 4s. already accepted. It has been stated that the implementation of the offer will mean an annual addition of about £12,000,000 to the railway wages bill.

It will be recalled that, originally, the three railway unions put forward a claim for a 15 per cent wage and salary increase, which was rejected by the British Transport Commission. Subsequently the Railway Staff National Tribunal made an award of a 4s. a week increase. This was not acceptable to the unions, and the National Union of Railwaymen had decided upon strike action just before Christmas, when, following an intervention by the Minister of Labour, the negotiations were reopened. The British Transport Commission then agreed to examine, with the unions, the whole wage and salary structure. At the same time the Commission and the unions agreed to confer in order to evolve ways of increasing the efficiency of the railways.

At the time of going to press, the unions have not announced their acceptance of the latest offer, and are holding further talks about it with the Transport Commission.

Miners' Wages

For some weeks past the National Union of Mineworkers has been negotiating a wage claim with the National Coal Board, and last week the Board announced details of the offer which it has made. Its main proposals are to increase the national minimum wage for underground workers by 8s. 6d. a week to £7 15s.; the national minimum for surface workers by 7s. 6d. a week to £6 15s.; shift rates of underground day wage workers by 1s. 5d. a shift, and of surface day wage workers by 1s. 3d. a shift. In addition, there are increases in the minimum shift rates payable in respect of overtime and week-end work, and increases in the shift and weekly minimum rates for juvenile workers.

This offer has been made subject to the acceptance by the union of certain conditions. The principal of these conditions is that the National Coal Board and the National Union of Mineworkers shall resolve jointly to continue and intensify throughout 1954 the steps taken to increase productivity in the coal mining industry. "It is considered that a 2½ per cent increase nationally in coal production this year, with the existing underground manpower is a reasonable minimum aim, and the suggestion has been made that the Board and the union shall together review, every three months, the progress made towards the achievement of that aim. In addition, the executive committee of the union is being asked to use its influence to secure the renewal of the extension of hours agreement for a further year from May 1st next, on the same terms and conditions as in the existing agreement, except that it shall be modified to provide for Saturday working only.

Exports of Engineering Products

The Board of Trade has stated that last year's exports of engineering products from the United Kingdom were valued at £1016 million, which was £31,000,000 less than in 1952. For the whole of the year 1952 this country's exports of engineering goods were 8 per cent greater than in 1951, an increase which, the Board of Trade says, was part of a general expansion in world trade in machinery and transport equipment. There was also some measure of improvement in this country's engineering exports in the first half of last year, but, according to the Board of Trade figures, it was lost in the latter half of the year.

One of the main factors in engineering exports over the past four years has been the growth in exports of aircraft and parts. Their value last year was nearly £65,000,000, which was almost double the figure recorded for 1950. Exports of locomotives and railway wagons which rose between 1951 and 1952 showed a further increase last year, and there was a slight increase, on the 1952 figure, in the value of ships delivered to overseas owners. Exports of passenger cars and chassis last year were valued at £104,000,000, which was £7,000,000 below the 1952 total, though during last year there was some recovery from the effects of Commonwealth import restrictions. Exports of commercial vehicles and of agricultural tractors were lower in value last year than in 1952.

Last year's exports of machinery were well above the totals recorded for 1950 and 1951, although they were below the level reached in 1952. In this classification, exports of machine tools and of office machinery were higher last year than in 1952, but exports of textile machinery were £10,000,000 below the value reached in 1952.

Industrial Relations and Human Relations

On Wednesday evening of last week, Sir Godfrey Ince, Permanent Secretary to the Ministry of Labour, addressed the Birmingham branch of the Institute of Personnel Management on the subject of "Industrial Relations and Human Relations." In the course of his talk, Sir Godfrey spoke of constitutional procedure for the settlement of industrial disputes, saying that the establishment of machinery for such procedure was in itself not enough, for the machinery would only work satisfactorily if a spirit of co-operation and goodwill existed between the two sides. Sir Godfrey said that it was characteristic of British institutions and typical of the British character that constitutionalism should have developed in industry as it had developed in other fields, but he wondered if that constitutionalism had gone far enough. In many industries, he remarked, there was provision in the constitutional machinery for finality in a dispute by way of arbitration, and his view was that there should be that same finality in all negotiating machinery.

In two or three industries recently, Sir Godfrey continued, there had been a reluctance on the part of some unions to agree to go to arbitration or to accept the results of arbitration. Those recent events, Sir Godfrey thought, had given a jolt to this country's system of industrial arbitration, but he felt that it was wholly unjustified to say that the system had been discredited. If it had been discredited, Sir Godfrey added, we were on the way to chaos in industrial relations. If there had been a loss of confidence in industrial arbitration in this country in the system which had been patiently built up over the last hundred years, it was essential for the future well-being of industry that steps should be taken to restore the lost confidence. That, Sir Godfrey suggested, was a responsibility and a duty which rested both on employers and the trade unions.

Notes and Memoranda

Rail and Road

SUMMER SCHOOL OF THE INSTITUTE OF THE MOTOR INDUSTRY.—We have received a copy of the curriculum of the eighth annual residential summer school which has been arranged by the Institute of the Motor Industry at St. Catharine's College, Cambridge, from August 21st to 28th next. Lectures and discussion groups have been arranged on the following subjects :—Law of interest to the motor trade, financial management and cost control, employment of capital and labour (including systems of payment by results), distribution and retail planning, principles and practice of sales promotion, modern merchandising and business management, the practice of management, personnel and welfare problems, industrial relations, principles of economics, presentation of technical information, workshop practice and management, stores control and accountancy, and a technical course. Reservations should be made before the end of March, the fees being twelve guineas to members and fourteen guineas to non-members. Further particulars may be obtained from the Institute at 40, Queen's Gate, London, S.W.7.

LIGHT ALLOY CABS AND BODIES.—British Road Services have conducted a series of experiments with road lorries fitted with cabs and bodies made of light-weight alloy. This construction, it is stated, enables the payload to be increased by as much as 13 cwt in the case of a representative eight-wheel rigid vehicle while still complying with the gross weight limit. These experiments have been carried out with two makes of eight-wheel rigid chassis. The body dimensions are identical with those of the normal vehicle of this design, which are the maximum permissible under the Construction and Use Regulations, and the lightweight construction enables a payload slightly in excess of 15 tons to be carried, compared with a little over 14 tons 7 cwt for the normal vehicle. While the main objective is to increase the available payload capacity, the lighter vehicle also has the advantage that, irrespective of its load, fuel and tyre costs are reduced. Besides the experiments carried out with the maximum capacity eight-wheel lorries, trials are proceeding with other kinds of vehicle, but British Road Services have now decided that the lightweight form of construction will be standard in future for eight-wheel flat platform and dropside vehicles.

Air and Water

GATWICK AIRPORT INQUIRY.—Mr. Harold Macmillan, Minister of Housing and Local Government, has appointed Sir Colin Campbell, former town clerk of Plymouth, to conduct the public local inquiry into objections to the Government's proposals for developing Gatwick Airport. The inquiry will open at the Constitutional Hall, Horley, on Tuesday, March 16th, at 11 a.m. and is expected to last for at least two or three days. Formal notice of the inquiry will be published later in the national and local press and objectors will be invited to send their objections to the Ministry. Objections should not be sent to the chairman of the inquiry. The notice will also give information about where maps and other matter explaining the scheme will be available for inspection.

THE INSTITUTION OF NAVAL ARCHITECTS.—The annual general meeting of the Institution of Naval Architects will be held on board the Honourable Company of Master Mariners' Headquarters Ship, "Wellington," Victoria Embankment, London, W.C.2, on Wednesday, April 7, Thursday, April 8th, and Friday, April 9th. The provisional programme of the papers to be read is as follows :—Wednesday, April 7th : "H.M. Yacht 'Britannia,'" by Sir Victor Shepheard. Thursday, April 8th : "A Note on Large Trawlers," by Professor Ir. H. E. Jaeger; "Underwater Television," by Lieut.-Commander J. N. Bathurst ; "Corrugations of Bottom Shell Plating," by Mr. J. M. Murray, and "The Application of Wave Resistance Calculations to Hull Design," by Mr. A. Emerson. Friday, April 9th: "Ship Performance and the Model Perfection," by Dr. J. F. Allan and Mr. H. J. S. Canham ; "Friction and Form Resistance in Turbulent Flow and a Proposed Formulation for Use in Model and Ship Correlation," by Dr. G. Hughes ; "Model Experiments on a Series of 0·65 Block Coefficient Forms : Part I, The Effect of Variation in L.C.B. Position and Bilge Radius on Resistance and Propulsion," by Mr. N. V. Almy and Dr. G. Hughes, and "Model Experiments on a Series of 0·65 Block Coefficient Forms : Part II, The Effect on Resistance of Variations in Breadth-Draught Ratio and Length-Displacement Ratio," by Mr. M. Meek and Mr. J. M. Ferguson.

Miscellanea

OBITUARY.—We have learned with regret of the deaths of Mr. Herbert William Whitlock and of Mr. Thomas Sydney Whitlock, two of the founder directors of Whitlock Brothers, Ltd., Great Yeldham, Essex. Mr. Herbert Whitlock, who was seventy-eight, died on January 17th, and his brother, Mr. Thomas Whitlock, who was seventy-nine, died on January 22nd.

STANDARD REFERENCE BLOCK FOR ULTRASONIC TESTING.—The F.E.18 Ultrasonics Panel of the British Welding Research Association is considering the need for a standard, single-hole, steel reference block for use in ultrasonic testing. Such blocks would need to be commercially available and should bear a mark showing that they are of approved design and quality. All firms and individuals interested in this possibility are asked to communicate with the Secretary, the F.E.18 Committee, British Welding Research Association, Abington Hall, Abington, Cambridge, from whom further information may be obtained.

ELECTROSTATIC PRECIPITATION.—We have received a copy of the tenth edition of *Electrostatic Precipitation*, published by Sturtevant Engineering Company, Ltd., Cannon Street, London, E.C.4. This booklet explains the principles and practice of Sturtevant electrostatic precipitation and describes the high-tension equipment and the mechanical rectifier. Illustrations are given to show the application of the system to power stations, cement works, chemical and metallurgical plant. A number of photomicrographs are reproduced to show the shapes and sizes of particles found in industrial atmospheres.

IRON AND STEEL SCRAP.—After consulting the Iron and Steel Board, the Minister of Supply has made an Order affecting the acquisition and certain prices of iron and steel scrap. The Order limits the need for a licence to acquire iron and steel scrap to persons engaged in the smelting of iron ore in a blast-furnace with other metalliferous materials, or the production of iron by any other process ; the production of steel by any process, and the casting of iron or steel by any process. The Order also removes tungsten steel scrap from price control and amends the instruction for calculating maximum prices where delivery is effected otherwise than by the British Transport Commission or licensed road hauliers. The Order, which is entitled the Iron and Steel Scrap (Amendment No. 2) Order, 1954, came into operation on January 21st.

MAXIMUM AMPLITUDE MEASURING SET.—Details of the maximum amplitude measuring set "74700–A," produced by Standard Telephones and Cables, Ltd., Connaught House, Aldwych, London, W.C.2, are given in a leaflet published by the company. The instrument is essentially a valve voltmeter with a range of 0V to 20V and is designed for measuring the maximum amplitude of transient phenomena, having a duration of at least 1 millisecond ; the accuracy of peak value measurement, then, is given as $\pm 0{\cdot}5$ per cent of full-scale deflection. To cater for transients having both positive and negative peaks the set has two meters connected in such a way that both maximum amplitudes are indicated in one measurement. The measuring set is produced as a portable instrument housed in an aluminium box measuring 17½in by 9½in by 8¼in, and it operates directly from 40 to 60 c/s mains.

REINFORCED PLASTICS CONFERENCE.—Leading plastics technologists of Government research establishments, aircraft and motor firms and plastics manufacturers recently held a three-day private conference at Stratford-on-Avon on reinforced plastics. The conference was called by the British Plastics Federation, which recently formed a committee known as the Asbestos and Fibre-Glass Reinforced Plastics Technical Committee to cater for all interests—manufacturers' and users'—in this rapidly developing material. Representatives at the conference were asked to disclose the nature of their research and development work and to discuss their problems. The proceedings were strictly private, no report being made even by the secretaries. Government departments represented were the Admiralty, the Ministry of Supply, the Royal Aircraft Establishment (Farnborough), and the Military Experimental Establishment (Christchurch). Aircraft and motor manufacturers also sent their experts.

GAMMEXANE IN THE TROPICS.—We have received a communication from the Telegraph Construction and Maintenance Company, Ltd., relating to the effect of Gammexane on polythene in the tropics. It has been noticed that chlorinated hydro-carbon insecticides such as Gammexane powder and DDT powder, when brought into contact with some grades of polythene under exceptional conditions, such as imposed by the Bell Telephone Laboratories environmental cracking test (see "Environmental Cracking of Stressed Polythene," by De Coste, Malm and Wallder, Bell Telephone Laboratories Inc.), cause the polythene to disintegrate. This phenomenon applies especially to polythene of grades 7 and softer. The test is an extremely severe one and the phenomenon has not been observed where polythene insulated cable has been treated with these insecticides. It would be interesting to know whether cable users in the tropics, where these insecticides are widely used, have experienced any trouble with polythene-insulated cables which may have come into contact with insecticides of this type.

BRITISH COUNCIL SCHOLARSHIPS.—The British Council has published a booklet giving details of over 100 scholarships offered to British students by sixteen foreign countries for study abroad during the academic year 1954–55. The scholarships are intended mainly for graduates and undergraduates of United Kingdom universities, but some are also open to those with non-academic professional qualifications. The awards generally provide for free tuition and maintenance, and are tenable for periods varying from four to twelve months. The closing date for receipt of applications varies for each country, the earliest date being March 8th next. The countries offering scholarships are Austria, Belgium, Brazil, Denmark, Finland, France, Germany, Iceland, Italy, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and Yugoslavia. Full particulars and application forms may be obtained, on receipt of a stamped, addressed, foolscap envelope, from any British Council office in the United Kingdom, or from the Controller, Education Division, The British Council, 65, Davies Street, London, W.1.

CEMENT FOR OWEN FALLS DAM.—One of the difficulties facing the builders of the dam at Owen Falls in Uganda was lack of a locally made cement. By the time cement has been shipped out to Mombasa and brought up country by rail the cost is more than doubled. The problem has now been solved by research at the Building Research Station, the D.S.I.R. informs us. A cement works, based on processes discovered at the Station, has been opened at Tororo, Uganda ; it is considered to be one of the most important steps in the industrialisation of the country, with an annual output of 60,000 tons. Local raw materials for cement production would normally have been rejected. The limestone available contains phosphates which, for reasons which were not understood, makes cement produced from it a weak and badly setting material. The Building Research Station was consulted by the Uganda Development Corporation. After carrying out some investigations, the Station was able to show how the phosphates affected the cement properties and how to get over the difficulties. This made cement manufacture possible and the building of a cement works could go ahead. Good quality cement can be made from the local limestone with up to 2 per cent phosphate content. A second process developed by the Station makes it possible to remove the phosphate entirely from the limestone. As phosphate is a useful fertiliser a valuable by-product could be obtained.

Personal and Business

MR. J. W. BARROW has been appointed deputy general manager of the M.S.S. Recording Company, Ltd., Colnbrook, Bucks.

MR. A. E. UNDERWOOD, a director of the Plessey Company, Ltd., has been appointed to the board of Plessey International, Ltd.

MR. R. G. GAME has been appointed manager of the London office of the Express Lift Company, Ltd., Greycoat Street, Westminster, S.W.1.

MR. LEONARD H. SHORT, M.I.E.E., has been appointed general export manager of The English Electric Company, Ltd., in succession to Mr. H. S. Aspinall, who has retired.

THE COLONIAL OFFICE states that Major-General W. D. A. Williams, C.B., is to succeed Sir Reginald Robins as Commissioner for Transport, East Africa High Commission.

Mr. C. G. WHITE, general sales manager and director of Kelvin Hughes (Marine), Ltd., has been elected chairman of the Radio Communication and Electronic Engineering Association.

FERODO, Ltd., has appointed Mr. D. L. Lewis as its technical representative serving the mining and heavy engineering industries in South Wales. His address is 60, Charles Street, Cardiff.

MR. J. E. GREATOREX has taken up an appointment with Mr. H. Q. A. Reeves, M.A., consulting engineer, 22, Lovelace Gardens, Surbiton, Surrey, with special responsibility for heating and ventilating design work.

MR. M. ARNET ROBINSON, deputy chairman of the Mersey Docks and Harbours Board, has been appointed a member of the Ports Efficiency Committee, in succession to Major Roland Thornton, who has resigned for health reasons.

MR. G. A. HANNAH, M.I.Mech.E., has been appointed managing director of Pegson, Ltd., Coalville, in succession to Mr. W. L. James, who has become chairman of the parent company, Mellor Bromley and Co., Ltd., Leicester.

ELLIOTT BROTHERS (LONDON), Ltd., states that its Manchester branch office has been transferred to 66, Deansgate, Manchester, 3 (telephone, Blackfriars 7752). Fisher Governor Company, Ltd., an associated firm, will also operate in the Manchester area from that address.

MR. A. J. W. BARTON has been appointed general manager of David Brown (Australasia), Ltd., in succession to the late Mr. P. J. Clifford. Mr. Barton was formerly director and manager of David Brown Tractor (Eire), Ltd., in which appointments he has been succeeded by Mr. J. B. Eeles.

VICKERS-ARMSTRONGS, Ltd., states that Mr. A. P. Wickens is to join its organisation on March 1st as manager, industrial tractors, at the Scotswood works. At the same time, he will become a special director of the company. At present Mr. Wickens is chief engineer at the Ministry of Supply Armament Design Establishment, Fort Halstead.

THE BRUSH ELECTRICAL ENGINEERING COMPANY, Ltd., Loughborough, announces the appointment of Mr. H. L. Wickes as sales specialist (motors). The company also announces the opening of a new area office for East Anglia at 4–5, Lloyds Chambers, Lloyds Avenue, Ipswich (telephone, Ipswich 2749). Mr. G. M. Ingram is the area manager.

JOHNSON AND PHILLIPS, Ltd., Charlton, S.E.7, states that Mr. B. E. Leeson has been appointed home sales manager (plant), with responsibility for switchgear, transformer and capacitor sales. Mr. Leeson, who for the past three years has been the company's senior sales engineer, will continue to operate from the Manchester office. Mr. C. W. Cawte has been appointed home sales manager (cables), and Mr. D. S. Barwell has been appointed sales promotion manager (export).

Contracts

THE BRUSH ELECTRICAL ENGINEERING COMPANY, Ltd., Loughborough, has received an order from the Government of Saurashtra, India, for the supply and erection of high- and low-voltage switchgear to the value of £60,000.

DECCA RADAR, Ltd., 1–3, Brixton Road, London, S.W.9, received a contract from the Ministry of Supply for a number of Decca "424" airfield control radars. These equipments will be used by the Royal Air Force to enable jet aircraft to be landed in rapid succession in poor visibility.

British Patent Specifications

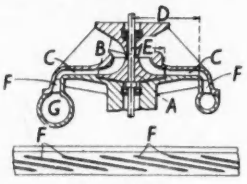
When an invention is communicated from abroad the name and address of the communicator are printed in Italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

COMPRESSORS AND BLOWERS

701,560. March 10, 1950.—CENTRIFUGAL COMPRESSORS, Centrax Power Units, Ltd., 87, High Street, Brentford, Middlesex, and Richard Henry Howard Barr, of the company's address.

The invention provides a centrifugal compressor of which the impeller discharges into a radial vaneless annular diffuser chamber in which substantial diffusion of the fluid occurs while its flow direction has no axial component. From the chamber the fluid passes immediately into a secondary diffuser consisting of divergent passages formed by a ring of guide vanes in association with a casing enclosing these vanes. The path of the fluid undergoes a



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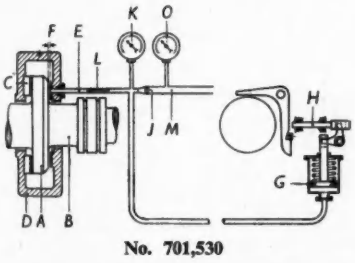
bend of approximately 90 deg. in passing from the vaneless chamber to the secondary diffuser. The compressor shown in the upper view comprises an impeller *A*, mounted on a shaft *B*. Air is discharged from the impeller into a primary diffusing space *C*, which is a vaneless annular chamber of which the outer radius *D* is about twice the impeller tip radius *E*. From the space *C* the air enters a secondary diffuser consisting of diverging passages defined by fixed vanes *F*. To reduce the overall frontal area of the compressor the diffuser casing is "dished" as shown, so that the air turns a right-angled bend in passing from the space *C* to the secondary diffuser and before entering a volute *G*. The fixed vanes *F* are located downstream of the bend and the necessary divergence of passage is provided by the walls of the diffuser casing, the vanes *F* themselves not being divergent relative to each other, as shown in the lower view.—*December* 30, 1953.

BEARINGS AND SUPPORTS

701,530. April 12, 1951.—SAFETY DEVICE FOR THRUST BEARINGS, Licentia Patent-Verwaltungs-G.m.b.H., 31–32, Hohe Bleichen, Hamburg 36, Germany.

The invention relates to safety devices for rotary machines with thrust bearings such as steam and gas turbines or compressors, in which the working fluid is cut off as soon as the thrust blocks of the bearing are worn beyond a certain permissible degree. As shown in the left-hand view, a thrust disc *A* of a shaft *B* of a prime mover co-acts with thrust blocks *C* arranged within a casing *D* of the thrust bearing. Into this casing there opens a pipe *E* which leads from a pump supplying the bearing oil and control oil. The orifice of the pipe *E* is



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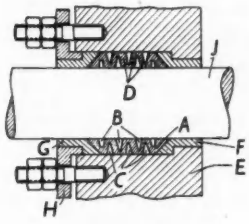
disposed opposite to, and at a short distance from, the one side face of the thrust disc *A* so that the clearance *F* between the orifice and the face will increase with increased wear of the thrust blocks. Thus the oil discharged from the pipe *E* is subjected to a throttle effect which will vary with the distance between the disc and the discharge orifice, and which will cause corresponding pressure variations in the pressure pipe *E*. The impulse for the operation of the control device which governs the supply of driving medium is derived from the pressure control oil. As shown in the right-hand view, the pressure of the control oil acts upon a spring loaded piston *G* which actuates a release device *H* of an emergency shut-off device. An orifice plate *J* built into the pressure oil pipe maintains the pressure of the control oil at the point of supply as far as possible constant. In order to make it possible for the operator to check at any time independently of the safety device the state of the axial displacement of the thrust disc of the thrust bearing, a pressure gauge *K* is connected to the pipe *E* between the orifice plate *J* and the clearance *F*. However, the oil pressure *L* and the pipe *E* behind the orifice plate *J*, which varies inversely with respect to the width of the clearance *F*, represents a correct measuring value for the instantaneous width of the clearance only if the pressure *M* in the supply pipe in front of the orifice plate remains constant. Another pressure gauge *O* indicates the pressure within the pipe *M*. If this pressure varies also, the relationship between pressure *L* and the width of the clearance *F* will change.—*December* 30, 1953.

701,595. March 20, 1951.—METALLIC PACKINGS FOR SLIDING RODS, Hans Sommer, a Swiss, 57, rue de la Station, Obourg, Belgium.

The packing shown in the drawing comprises a metal sleeve *A* preferably of a non-ferrous metal, in which have been formed a number of internal grooves *B* and of external grooves *C*. These internal and external grooves are separated from each other by walls *D* which in longitudinal section are oblique relatively to the axis of the packing sleeve. The sleeve is housed in a bearing *E* between bronze rings *F* and *G* which can move towards each other.



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The ring *G* can be pushed towards the ring *F* by screwing in nuts on studs projecting from the bearing nuts which bear against a gland *H*. The elasticity of the sleeve *A* is such that under the effect of the axial compression its walls change their inclination relatively to the axis and reduce the clearance between the packing and the sliding rod *J*. The sleeve is split lengthwise into at least two portions, none of which subtends an angle greater than 180 deg. On this account, the assembly and dismantling of the packing can be effected without necessitating the removal of the parts which are connected with the sliding rod *J*. A modified design is also shown in the specification.—*December* 30, 1953.

METALLURGY

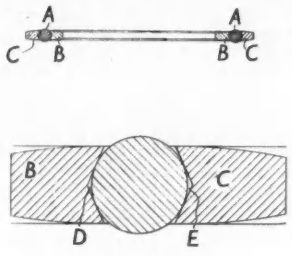
701,541. July 5, 1951.—MOULDS FOR CASTING STEEL AND IRON, The Buderus'sche Eisenwerke, 52–56, Sophienstrasse, Wetzlar, Germany.

The invention relates to improvement in the prior invention described and claimed in Specification No. 696,301. According to the invention, the mould is composed of a sintered mixture of industrial iron powder and substantially hydrate-free Al_2O_3 powder in substantially equal proportions by weight. By "industrial iron" is meant iron such as is produced and used industrially, which may contain small quantities of other elements, such as carbon, silicon, manganese phosphorus and sulphur, as distinguished from chemically pure iron. It is advantageous also to add a gas-free fluxing agent to the powdered mixture before sintering in order to reduce the sintering temperature. For this purpose, low melting point fluxing agents for the sintering process, formed of metals and metallic compounds, are particularly suitable. It has also proved to be expedient to add copper in an amount up to about ten parts by weight of the mixture. Also suitable as fluxing agents, according to the invention, are mixtures or compounds containing or derived from titanic acid, e.g. sodium silicotitanate. It is important that the added agent should be free from gas so as to ensure the production of an air-tight casting mould. Consequently, in certain cases, the fluxing agent must be made gas-free in a separate process before it is added to the powdered mixture intended for the production of the casting mould.—*December* 30, 1953.

JOINT SEALS

701,614. June 27, 1951.—THE SEALING OF JOINTS IN HIGH VACUUM SYSTEMS, Metropolitan-Vickers Electrical Company, Ltd., St. Paul's Corner, 1–3, St. Paul's Churchyard, London, E.C.4. (*Inventor: Godfrey Burrows.*)

Referring to the drawing, the sealing ring assembly comprises a tore ring *A* of elastic material such as Neoprene, contained between concentric retaining rings *B* and *C* of relatively non-deformable material such as mild steel. The rings are formed in their facing surfaces with respective shallow "vee" grooves *D* and *E* in which the tore ring lies, the dimensions being such that when not in use the tore ring stands slightly proud of the retaining rings and makes line contact with the surfaces of the groove. The drawing shows clearly chamfering on the side



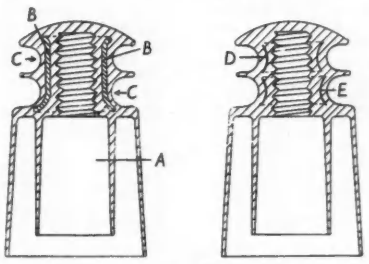
No. 701,614

surfaces of the retaining rings. In carrying out the invention it is preferred to use as far as possible standard sized tore rings, and the retaining rings will be shaped to correspond. The calculation of the size of the tore ring is described in the specification.—*December* 30, 1953.

ELECTRICAL ENGINEERING

701,872. February 6, 1952.—ELECTRIC INSULATORS, Nield's Patents, Ltd., Penarth Road, Cardiff. (*Inventor: Douglas Nield.*)

The invention comprises improvements in or relating to electric insulators moulded from plastics. The insulator *A* shown in the left-hand drawing is moulded from a plastic, such as polythene or polyvinyl chloride and inset in the moulding is a collar *B* which may be of metal, porcelain, a hard plastic or any other suitable material, and extends across the



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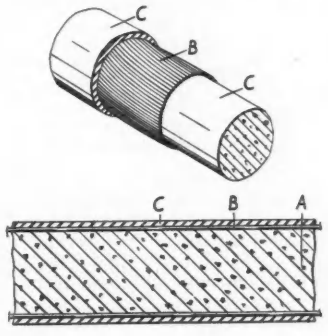
grooves *C* for the conductor. The inset collar *B*, being hard and unaffected by tropical heat, would prevent the conductor cutting through the insulator. In the right-hand view of the drawing a similar insulator is shown, which has two separate collars or rings *D* and *E* inset in the plastic moulding, which will prevent a conductor cutting through the insulator in the event of softening under tropical heat. Bobbin insulators of similar design are also shown in the specification.—*January* 6, 1954.

700,648. October 26, 1951.—ELECTRIC CABLES, British Insulated Callender's Cables, Ltd., Norfolk House, Norfolk Street, London, W.C.2. (*Inventor: Douglas Taft Hollingsworth.*)

The invention relates to the construction of electric cables for carrying relatively large currents which are flexible and capable of floating on water. As shown



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in the drawing, the cable comprises a core *A*, over which is applied a layer of relatively fine wires *B*. The wires are applied helically and are insulated by a water-excluding covering *C*, which is of vulcanised rubber and may be built up from unvulcanised rubber tapes applied helically over the wires, the rubber

being finally vulcanised. The core *A* is made from cork granules bonded together and then moulded. It has enough flexibility to enable it to be coiled upon a drum. It also has the strength required to enable it to resist radial compression during the application of the wires to it in the stranding machine and when the cable is in service. The bonding of the cork granules can be effected by the application of pressure and a binding medium, such as the natural rosin of the cork which is made available by the application of heat simultaneously with pressure. Alternatively, a separate binding medium may be added. The invention is also applicable to electric cables intended to serve as buoyant electrodes, in which case the cable insulation will be replaced by a covering or coverings permitting the passage of water through to the cable conductor.—*December* 9, 1953.

Codes of Practice

FARM AND HORTICULTURAL ELECTRICAL INSTALLATIONS

Code 112.201.—The Council for Codes of Practice for Buildings has now issued in final form Code 325, "Farm and Horticultural Electrical Installations." It was drawn up by a committee convened on behalf of the Council by the Institution of Electrical Engineers, and is a revision of the draft previously issued for comment. It incorporates the following head-code and sub-codes: Code 325, "Farm and Horticultural Electrical Installations (General Aspects)"; Sub-code 325.101, "Farm Consumers' Distribution"; 325.102, "Farm Wiring"; 325.103, "Farm Lighting"; 325.104, "Farm Heating Installations"; 325.105, "Farm Motive Power"; 325.106, "Horticultural Installations." The code is applicable both to new installations and to the modernisation and extension of existing installations. It does not take the place of a detailed specification, and the assumption is made that the work is carried out under qualified supervision. The head Code deals with the more general aspects of the subject. It points out the need for liaison at the planning stage to determine the location of the main controls and the layout of the consumer's distribution for the immediate applications proposed and possible future extensions. It surveys the operating conditions to which installations may be subjected and deals with earthing, battery-charging and the electric fences. Copies may be obtained from the British Standards Institution, 2, Park Street, London, W.1, price 15s.

Launches and Trial Trips

DISPATCHER, bauxite carrier; built by the Burntisland Shipbuilding Company, Ltd., for the Pan-Ore Steamship Company, Inc.; length between perpendiculars 425ft, breadth moulded 60ft, depth moulded 29ft 6in, deadweight 8035 tons, draught loaded 20ft 6in, speed 12 knots; two long holds, mechanical air conditioning and ventilation; one set of double reduction geared turbines, built by David Rowan and Co., Ltd., 3300 s.h.p. at 112 r.p.m. of propeller, steam at 400 lb. per square inch and 725 deg. Fah. by two Babcock and Wilcox water-tube boilers. Trial, January 18th.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases, the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH INSTITUTION OF RADIO ENGINEERS

Thurs., Feb. 4th.—SCOTTISH SECTION: Institution of Engineers and Shipbuilders, Elmbank Crescent, Glasgow, "Electronics in Film Making," W. D. Kemp and B. R. Greenhead, 7 p.m.——N.W. SECTION: Reynold's Hall, College of Technology, Sackville Street, Manchester, 1, "Police Radio, its Past, Present and Future Possibilities," I. Auchterlonie, 7 p.m.——MERSEYSIDE SECTION: Electricity Service Centre, Whitechapel, Liverpool, 1, "Micro-Wave Test Gear," J. Bilbrough, 7 p.m.

Wed., Feb. 10th.—N.E. SECTION: Neville Hall, Westgate Road, Newcastle upon Tyne, "Some Aspects of Micro-Wave Aerial Design," J. Bilbrough, 6 p.m.

CLEVELAND INSTITUTION OF ENGINEERS

Mon., Feb. 1st.—Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "The Operation of Soaking Pits," J. Dodd, 6.30 p.m.

INCORPORATED PLANT ENGINEERS

Tues., Feb. 2nd.—LONDON BRANCH: Royal Society of Arts, John Adam Street, Adelphi, W.C.2, Open Forum, 7 p.m.——EDINBURGH BRANCH: 25, Charlotte Square, Edinburgh, "The Efficiency of a Modern Steam Plant," H. E. Partridge, 7 p.m.

Wed., Feb. 3rd.—SOUTHAMPTON BRANCH: Polygon Hotel, Southampton, "Heat Pumps," Oliver Lyle, 7.30 p.m.

Thurs., Feb. 4th.—PETERBOROUGH BRANCH: Eastern Gas Board's Demonstration Theatre, Church Street, Peterborough, "Feed Water Treatment," Hector Taylor, 7.30 p.m.

Mon., Feb. 8th.—DUNDEE BRANCH: Mathers Hotel, Dundee, "Hydraulics: General Principles and Application," "Introduction to the Heat Engine," "The Diesel Generator as a Composite Heat and Power Unit," "The Grangemouth Project," 7.30 p.m.

Wed., Feb. 10th.—E. MIDLANDS BRANCH: Demonstration Theatre, Gas Board Showrooms, Parliament Street, Nottingham, "Air Conditioning," A. Peel, 7 p.m.

Thurs., Feb. 11th.—N.E. BRANCH: Roadway House, Oxford Street, Newcastle upon Tyne, "Metallurgy," J. Rolston, 7 p.m.

INSTITUTE OF MARINE ENGINEERS

Tues., Feb. 9th.—85, Minories, London, E.C.3, A Symposium, "Some Interesting Ship and Machinery Defects: Their Investigation and Cure," 5.30 p.m.

INSTITUTE OF METALS

Tues., Feb. 2nd.—OXFORD LOCAL SECTION: Cadena Café, Cornmarket Street, Oxford, Junior Members' Evening, Discussion on New Topics, 7 p.m.

Thurs., Feb. 4th.—BIRMINGHAM LOCAL SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "The Fracture of Steel," J. E. Russell, 6.30 p.m.——LONDON LOCAL SECTION: 4, Grosvenor Gardens, S.W.1, "Germanium and Silicon," R. W. Douglas, 6.30 p.m.

Mon., Feb. 8th.—SCOTTISH LOCAL SECTION: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Some Practical Hints on the Production of Non-Ferrous Castings," William Dunlop, 6.30 p.m.

INSTITUTE OF NAVIGATION

Fri., Feb. 19th.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "The Requirements for Marine Pilotage," L. W. Akerman and R. F. Hansford, 5 p.m.

INSTITUTE OF PETROLEUM

Wed., Feb. 10th.—26, Portland Place, London, W.1, "Accident Prevention," T. T. Maclean, 5.30 p.m.

INSTITUTE OF TRANSPORT

Mon., Feb. 8th.—Jarvis Hall, 66, Portland Place, London, W.1, Brancker Memorial Lecture, "The Impact of the Gas Turbine on Civil Aviation," Sir Miles Thomas, 5.45 p.m.

INSTITUTE OF WELDING

Thurs., Feb. 4th.—N. LONDON BRANCH: Manson House, Portland Place, W.1, "Avoiding Fatigue in Welded Structures," R. Weck, 7.30 p.m.

Thurs., Feb. 11th.—SLOUGH SECTION: Community Centre, Farnham Road, Slough, Bucks, "Resistance Welding in Production," E. A. Whittaker, 7.30 p.m.——S. LONDON BRANCH: 2, Savoy Hill, London, W.C.2, Discussion on "Training and Testing of Arc Welders," opened by A. E. Swetnam, B. E. Lambie and A. B. Tompkins, 6.30 p.m.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Tues., Feb. 16th.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Mechanisation of Bracken Eradication," G. Henderson, 2.15 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Sat., Jan. 30th.—MIDLANDS BRANCH: The University, Edmund Street, Birmingham, Annual General Meeting, "Some Aspects of Biochemical Engineering," B. Edgington, 2.30 p.m.

Tues., Feb. 2nd.—Geological Society, Piccadilly, London, W.1, "Sedimentation and Fluidisation," J. F. Richardson and W. N. Zaki, 5.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

To-day, January 29th.—YORKSHIRE ASSOCIATION: Royal Victoria Station Hotel, Sheffield, "Weakness of Cast Iron in Tension," with reference to Six Shaft Sinking Accidents, 1905–52," I. C. Easton, 7 p.m.

Tues., Feb. 2nd.—MARITIME MEETING: Great George Street, Westminster, London, S.W.1, "Site Exploration for Maritime and River Works," M. J. Tomlinson, 5.30 p.m.——N.W. ASSOCIATION: Reynold's Hall, College of Technology, Manchester, "Load Factor Design in Reinforced Concrete," F. G. Thomas, 6.45 p.m.

Tues., Feb. 9th.—PUBLIC HEALTH MEETING: Great George Street, Westminster, London, S.W.1, "Public Health Engineering in Developed and Underdeveloped Countries," R. F. Burden, 5.30 p.m.

Thurs., Feb. 11th.—N.W. ASSOCIATION, STUDENTS' MEETING: Engineers' Club, Albert Square, Manchester, Discussion on "The First Years of Professional Employment," 6.30 p.m.——MIDLANDS ASSOCIATION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Some Problems in Railway Civil Engineering Maintenance," A. H. Cantrell, 6 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Feb. 1st.—S. MIDLAND CENTRE: James Watt Memorial Institute, Great Charles Street, Birmingham, "A Recent Application of Diesel-Electric Propulsion," P. W. R. Gatliff; "Some Aspects of the French Distribution System," K. Shaw; "The Production and Testing of Transistors," J. Hughes, 6 p.m.

Tues., Feb. 2nd.—MEASUREMENTS AND SUPPLY SECTIONS: Savoy Place, London, W.C.2, "Measurement of the Winding Resistances of a 132kV Power Transformer in Service," K. J. R. Wilkinson and J. D. Harmer, 5.30 p.m.——N. MIDLAND CENTRE: British Electricity Authority, 1, Whitehall Road, Leeds, 1, "The Testing and Specification of Bushings in Relation to Service Conditions," H. Barker and H. Davies, 6.30 p.m.

Wed., Feb. 3rd.—S.W. SCOTLAND SUB-CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Industrial Switchgear," K. M. Street, 7 p.m.

Thurs., Feb. 4th.—ORDINARY MEETING: Savoy Place, London, W.C.2, "The Manchester-Kirk o' Shotts Television Radio Relay System," G. Dawson, L. L. Hall, K. G. Hodgson, R. A. Meers, and J. H. H. Merriman, 5.30 p.m.

Mon., Feb. 8th.—INFORMAL MEETING: Savoy Place, London, W.C.2, Discussion on "Will it be Possible to Abolish Meters Entirely?" opened by H. S. Petch and M. Whitehead, 5.30 p.m.

Tues., Feb. 9th.—S.E. SCOTLAND SUB-CENTRE: Carlton Hotel, North Bridge, Edinburgh, "Fluorescent Discharge Circuits and Operating Problems," J. Cates, 7 p.m.——N. MIDLAND CENTRE: British Electricity Authority, 1, Whitehall Road, Leeds, 1, "Special Effects for Television Studio Production," A. M. Spooner and T. Worswick, 6.30 p.m.

Wed., Feb. 10th.—N. SCOTLAND SUB-CENTRE: Caledonian Hotel, Aberdeen, "Fluorescent Discharge Tube Circuits and Operating Problems," J. Cates, 7.30 p.m.——RADIO SECTION: Savoy Place, London, W.C.2, "Basic Ground-Wave Propagation Characteristics in the 50–800 Mc/s Band," J. A. Saxton; "Ground-Wave Field Strength Surveys at 100 and 600 Mc/s," J. A. Saxton and B. N. Harden, 5.30 p.m.

Thurs., Feb. 11th.—EXTRA MEETING: Savoy Place, London, W.C.2, "A Short Modern Review of Fundamental Electromagnetic Theory," P. Hammond, 5.30 p.m.——N. SCOTLAND SUB-CENTRE: Royal Hotel, Dundee, "Fluorescent Discharge Tube Circuits and Operating Problems," J. Cates, 7 p.m.——LONDON STUDENTS' SECTION: Public Library, Chelmsford, "Industrial Consumer Installation Practice," J. J. Peacock, 7 p.m.

INSTITUTION OF ENGINEERING INSPECTION

Tues., Feb. 2nd.—S.W. BRANCH: Grand Hotel, Broad Street, Bristol, "Practical Applications of the Interference of Light," C. B. Daish, 7.30 p.m.

Wed., Feb. 3rd.—BIRMINGHAM BRANCH: Chamber of Commerce, New Street, Birmingham, "The Organisation of Inspection on the Lines of Statistical Quality Control," J. Forster-Cooper, 7.20 p.m.——COVENTRY BRANCH: Technical College, Coventry, "Quality Control in the U.S.A.," S. W. Nixon, 7.30 p.m.

Thurs., Feb. 4th.—LONDON BRANCH: Royal Society of Arts, John Adam Street, Adelphi, W.C.1, "Copper and its Applications," G. W. Preston, 7 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Feb. 9th.—39, Elmbank Crescent, Glasgow, "Electronic Instruments Developed for Marine Turbine Research," J. Hare and R. B. Conn, 6.45 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Thurs., Feb. 4th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, Film Evening, 5.30 p.m.

Wed., Feb. 10th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, "The Measurement of Train Resistance," H. I. Andrews, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Mon., Feb. 1st.—N.E. BRANCH: Neville Hall, Westgate Road, Newcastle upon Tyne, "High Temperature Turbine Machinery for Marine Propulsion," T. W. F. Brown, 6 p.m.

Tues., Feb. 2nd.—COVENTRY BRANCH: Craven Arms Hotel, High Street, Coventry, Address by Centre Chairman, Leonard Griffiths, 7.15 p.m.

Wed., Feb. 3rd.—INTERNAL COMBUSTION ENGINE GROUP DISCUSSION: Storey's Gate, St. James's Park, London, S.W.1, "The Extent to which the Gas Turbine May Supplant or Supplement the Piston Engine in the Next Ten or Twenty Years," 6.45 p.m.——SOUTHERN BRANCH: Technical College, Maidstone, "History of Patents," R. E. Tree, 7 p.m.

Thurs., Feb. 4th.—N.W. BRANCH: Engineers' Club, Albert Square, Manchester, "Steelwork Engineering with Particular Reference to Continuous Strip Mills," R. L. Willott, 6.45 p.m.

Mon., Feb. 8th.—DERBY A.D. CENTRE: Midland Hotel, Derby, "The Jaguar Engine," W. M. Heynes, 7.15 p.m.——LUTON A.D. CENTRE: Town Hall, Luton, "Tyre Development," T. Joy and D. C. Hartley, 7.30 p.m

Wed., Feb. 10th.—E. MIDLANDS BRANCH: The University, Nottingham, "Three Dimensional Stress Analysis by Photo-Elastic Methods," H. Fessler, 7.30 p.m.

Thurs., Feb. 11th.—YORKSHIRE BRANCH: The University, Leeds, "Recent Developments in Constructional and Tool Steels," E. Johnson, 7 p.m.

Fri., Feb. 12th.—GENERAL MEETING, APPLIED MECHANICS GROUP: Storey's Gate, St. James's Park, London, S.W.1, Third Report of the Pipe Flanges Research Committee, presented by A. E. Johnson, 5.30 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Tues., Feb. 9th.—ORDINARY MEETING: Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Step-by-Step Auto-Exchange Maintenance in the U.S.A.," E. Hopkinson and J. Prescott, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Tues., Feb. 2nd.—PETERBOROUGH SECTION: Campbell Hotel, Bridge Street, Peterborough, "Design for Welding," 7.30 p.m.

Wed., Feb. 3rd.—NOTTINGHAM SECTION: Victoria Station Hotel, Milton Street, Nottingham, "Some Researches in Deep Drawing," W. H. Swift, 7 p.m.——WOLVERHAMPTON SECTION: Technical College, Wolverhampton, "Electronics in Production Engineering," D. R. Whatley, 7.15 p.m.

Thurs., Feb. 4th.—LONDON SECTION: Old Ship Hotel, Brighton, "Mechanical Handling Techniques," J. Bain, 7 p.m.——READING SECTION: Transport Equipment (Thornycroft), Ltd., Worting Road, Basingstoke, "The Fundamentals of Production Management," M. Seaman, 7.30 p.m.

INSTITUTION OF SANITARY ENGINEERS

Tues., Feb. 2nd.—Caxton Hall, Westminster, London, S.W.1, Discussion on New Code of Practice, "Soil and Waste Pipes Above Ground," opened by C. L. Langshaw and J. B. Escritt, 6 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Tues., Feb. 2nd.—Cleveland Scientific and Technical Institution, Corporation Street, Middlesbrough, "Prestressed Concrete in Civil Engineering Works," A. J. Harris, 6.30 p.m.

Fri., Feb. 5th.—WESTERN COUNTIES BRANCH: The University Geology Lecture Theatre, Bristol, "The Industrial Architect and Engineer," J. E. Collins, 6 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, January 29th.—INFORMAL MEETING: Townsend House, Greycoat Place, London, S.W.1, "Wheel Equipment with particular reference to Aircraft," C. D. Holland, 7 p.m.

Wed., Feb. 3rd.—MIDLAND SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Sintered Component Manufacture," B. H. Swann, 7 p.m.

Fri., Feb. 5th.—Townsend House, Greycoat Place, London, S.W.1, Films, "The Story of Steel," "Steel," "Great Achievement," introduced by P. Cameron, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

Fri., Feb. 5th.—Engineers' Club, Albert Square, Manchester, "Some Notes on the Design and Construction of Large Aircraft," H. Rogerson, 6.45 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, January 29th.—Mining Institute, Newcastle upon Tyne, "Stress Investigation on a Tanker During Launching," A. J. Johnson and M. Meek, 6.15 p.m.

REINFORCED CONCRETE ASSOCIATION

Tues., Feb. 2nd.—N.W. BRANCH: College of Technology, Sackville Street, Manchester, "Load Factor Design in Reinforced Concrete," F. G. Thomas, 6.45 p.m.

Wed., Feb. 3rd.—N.W. BRANCH: Liverpool Engineering Society, 24, The Temple, Dale Street, Liverpool, "Load Factor Design in Reinforced Concrete," F. G. Thomas, 6.30 p.m.

ROYAL AERONAUTICAL SOCIETY

Thurs., Feb. 4th.—4, Hamilton Place, London, W.1, "Air Intake Efficiency," F. B. Greatrex, 7 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., Feb. 1st.—ORDINARY GENERAL MEETING: 12, Great George Street, Westminster, S.W.1, "Current Problems of the Property Manager," F. W. Kenchington, 5.30 p.m.

SOCIETY OF ENGINEERS

Mon., Feb. 1st.—Geological Society, Burlington House, Piccadilly, London, W.1, Presidential Address, W. R. Howard, 5.30 p.m.